QUARTERLY JOURNAL OF METHODS AND INFORMATION FOR TEACHERS OF SCIENCE

Index

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Volume XII ★ Number 4 ★ Dec., 1949

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In Future Numbers...

★ ★ ★ ★ ★

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Plant Growth Hormones
A. A. Haagen-Smit, Department of Biology, California Institute of Technology, Pasadena, California.

A Step in Industry-Education Cooperation
Nathan A. Neal, President, National Science Teachers Association; Harper & Brothers Publishing Co., New York.

Synthetic Food Flavors
David E. Lakritz, Chief Chemist, Florasynth Laboratories, Inc., New York, New York.

The Story of Chemical Abstracts
E. J. Crane, Editor, Chemical Abstracts, Ohio State University, Columbus, Ohio.

Garden Farming in Japan
C. L. Swanson, Head, Department of Soils, Connecticut Agricultural Experimental Station, Storrs, Connecticut.

Teaching Nutrition in Secondary Schools
Betty Lockwood, Department of Nutrition, Harvard University, School of Public Health, Boston, Massachusetts.

Seeing is Believing
Ernst A. Hauser, Professor of Colloid Chemistry, Massachusetts Institute of Technology, Cambridge, Massachusetts.

College Training Programs for High School Science Teachers
Philip G. Johnson, Specialist for Science, Secondary Schools, United States Office of Education, Washington, D. C.

Optical Glass
L. S. Collins, Bausch & Lomb Optical Company, Rochester, New York.

Native American Gemstones

● By **Richard M. Pearl, A.M.,** *(Harvard University)*
DEPARTMENT OF GEOLOGY, COLORADO COLLEGE, COLORADO SPRINGS, COLORADO

The increased emphasis recently given to the earth sciences in secondary schools probably accounts for the rapidly growing layman interest in mineral collecting and mineral study, and for the popularity of amateur lapidary work.

This article directs attention to certain gemstones that are native to America. Some of them may be found in your district. Do you know variscite, the fourth in value of the gems produced in the United States? The Montana sapphire, our most intensively mined gem? What about diamond production in this country?

Professor Pearl is the author of "Popular Gemology" reviewed elsewhere in this issue.

●

When Europeans came to this hemisphere they found the Indians of North and South America familiar with as many varieties of gemstones as were known in the rest of the world. At least twenty kinds of gems were used by the beginning of the Christian era, and another dozen or so by 1000 A.D. These were obtained mostly from stream or placer deposits. Nevertheless, the Indian did much quarrying and had especially large workings of turquoise and obsidian. Some of his gem deposits had been worked for fifteen hundred years or more, and certain turquoise mines were of great economic and political importance in the period before the arrival of the conquistadores.

Arrowheads and spear points were fashioned from a number of kinds of gem minerals; other articles such as mirrors were made from some of them; and well-shaped natural crystals were buried with the dead. The native races attached supernatural powers to stones that were attractive because of their color and a wealth of fascinating gem lore centers entirely about the symbolism of color.

Four interesting gems—benitoite, variscite, rhodolite, and hiddenite—have been produced only in the United States. Benitoite is a uniquely American gem, occurring in just one place in the world, San Benito County, California. When found in 1907 this silicate of barium and titanium was at first mistaken for sapphire, which it resembles in its rich blue color. Benitoite crystallizes in the ditrigonal-dipyramidal class of the hexagonal system, and its discovery furnished proof of the existence of a crystal class previously known only mathematically.

Danburite, a silicate of calcium and boron, found at Danbury in Connecticut, is the only species of gemstone other than benitoite to bear the name of an American mineral locality.

Although named for an old district in Germany known to the Romans as Variscia, the mineral variscite is exclusively an American gemstone. The color, usually light green to bluish green, resembles some hues of turquoise. As variscite has become more familiar the demand for it under its own name has grown. When in 1947 it ranked fourth in value among the gems produced in the United States, variscite finally received full recognition. This hydrous aluminum phosphate is colored by chromium, vanadium, and iron. It occurs in nodules which when sectioned show a mixture of several rare phosphate minerals in a pattern of intricate veining. The desert areas of northern Utah supply these specimens.

Rhodolite is a garnet intermediate between pyrope and almandite. Tiny gemstones cut from it have come only from Macon County in western North Carolina, where the material was first reported in 1893, although crystals were also discovered in Greenland during the recent war. The name of this attractive gem indicates its rose color.

Hiddenite was another American gemstone found in only one place, near Stony Point, North Carolina, until a recent minor discovery in South Dakota added another locality for this native gem. It is an emerald-green variety of spodumene, a silicate of lithium and aluminum belonging to the important pyroxene group of minerals. Crystals of common spodumene grow to greater lengths than any other mineral, but hiddenite itself is restricted to delicate specimens, too few and too small to have had much influence on the gem market. Enthusiastic newspaper stories created an immediate demand for the new stone when it was found in 1879; quick depletion of the deposit resulted and the mine was closed as a result of litigation. The gem was named after its discoverer, William C. Hidden.

A second gem variety of spodumene, this one having an appealing lilac and pink color, was also named after an American. First found in 1902 in San Diego County, California, the stone was named kunzite for George F. Kunz of the jewelry firm of Tiffany.

The most intensively mined gem in the United States has been the Montana sapphire. The first of these beautiful stones was discovered in 1873 in the gravel bars of the Missouri River east of Helena by prospectors searching for placer gold. In 1889 others were found in Powell County along Dry Cottonwood Creek and were recovered by dredging. Companies were organized two years later to work the deposits. The main source was found in 1896 by miners who were discouraged by the high cost of producing gold that did not pay expenses. They were rewarded by uncovering a dike at Yogo Creek which became the world's largest and

(Continued on Page 143)

Photosynthesis

● By **A. A. Benson, Ph.D.,** *(California Institute of Technology)* **and M. Calvin, Ph.D.,** *(University of Minnesota)*
DEPARTMENT OF CHEMISTRY AND RADIATION LABORATORY, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

This up-to-the-minute paper tells how radioactive carbon isotopes are used as research tools in determining how green plants convert carbon dioxide and water into the materials of which the plant is composed.

The nature of the intermediates between carbon dioxide and sugar was unknown until radioactive carbon dioxide became available. Now a considerable number of intermediates have been identified by the use of two dimensional paper chromatography, and the probable carbon-to-sugar path has been charted.

●

Photosynthesis is the prime synthetic mechanism of the biosphere. Yet this process by which green plants store the energy they receive from the sun is by no means clearly understood. We know that plants absorb carbon dioxide from the air or water in which they live and convert it to fats, proteins, and carbohydrates and the multiplicity of compounds which have been discovered in plant tissue. Carbon is in its lowest energy form in carbon dioxide. By photosynthesis it is converted to compounds with considerable energy content. It is this stored energy which animals and bacteria require for survival. The energy of man's food and most of his fuel is harnessed by the absorption of light in chlorophyll.

During photosynthesis water and carbon dioxide react to give oxygen gas and reduced carbon compounds as expressed classically:

$$CO_2 + H_2O \xrightarrow{h\nu\ (\text{light})} (CH_2O)_x + O_2$$

Recently, light absorption and oxygen evolution have been shown to be independent of the process of carbon dioxide reduction. By illuminating pure chloroplast suspensions in the presence of an oxidizing agent like quinone, V. R. Hill was able to demonstrate oxygen liberation. With water containing the heavy oxygen isotope O^{18} it was shown by S. Ruben in Berkeley and A. P. Vinogradov in Russia that the oxygen gas came directly from the water and not from the carbon dioxide. The photochemical phase of photosynthesis, the absorption of light by the chlorophyll in the chloroplasts and splitting of water into a reducing agent and oxygen gas, is apparently quite separate from the path of carbon in photosynthesis.

For the last hundred years workers have studied the uptake of carbon dioxide by plants. The experiments always involved measurement of rate of disappearance of starting material and the rate of appearance of the final products. At no time was it possible to visualize the details of the chemical process involved. A new era in this study began in 1939 when the late Professor S. Ruben of the University of California used radioactive carbon C^{11} to trace the path of carbon. He and Professor Martin Kamen worked furiously to gain their information, since the half life of C^{11} is 20.5 minutes and an experiment could last only a few hours. They did learn that carbon dioxide is reversibly absorbed by plants in the dark. Such information was only possible with "tagged" atoms since the exchange involved no net uptake of carbon dioxide. Ruben assumed from his results that photosynthesis involved a dark fixation in the carboxyl group of some unknown compound.

With the present availability of the long-lived isotope C^{14} we have continued these early experiments. It was found that the dark uptake of carbon dioxide could be increased one hundred-fold by illuminating the plants in the absence of carbon dioxide for a few minutes immediately previous to giving the plants radioactive carbon dioxide in the dark. The rate of this assimilation approached the normal rate of photosynthesis and

Figure 1.
Preparing a Paper Chromatogram

it became apparent that reduction of carbon dioxide might not require simultaneous absorption of light but could proceed for a time with stored energy. How the plant stores the light energy is not yet certain. Apparently a surplus of reducing agents is built up during preillumination which can later act on the intermediates of carbon reduction.

The nature of the intermediates between carbon dioxide and sugar had not been known and could not be easily determined without the use of isotopes. Many theories such as the reduction of carbon dioxide to formaldehyde had been suggested but could not be proved. With an extract from a plant which had photosynthesized in $C^{14}O_2$ for a short time it was now possible to identify the intermediates involved. At first the identifications were slow and tedious. It became apparent that a large number of compounds became radioactive in periods of photosynthesis as short as thirty seconds. To get the overall picture some method had to be applied which would rapidly separate and identify many compounds. The method of two dimensional paper chromatography which was developed by Martin, Consden and Synge in 1944 proved to be the ideal solution to the problem. The components of a plant extract, radioactive or not, may now be rapidly separated.

To prepare a paper chromatogram one applies a small amount (a few micrograms) of the mixture to be separated to a circle near a corner of a large sheet of filter paper. An edge of the sheet is immersed in a long trough containing wet phenol. The liquid slowly flows through the suspended paper until it reaches the lower edge. It is then removed from the closed cabinet (Fig. 1) and dried. During this process the phenol which flowed past the spot of extract at the "origin" moved some compounds faster than others to form a row of spots, some of them overlapping. The process involves distribution of the compounds in the "origin" spot between the moving organic solvent phase and a fixed solvent phase which consists of water absorbed on the surface of the paper.

Figure 2.

A RADIOGRAM shows where each radioactive component is located. This one shows a few of the many compounds a plant can synthesize in ninety seconds.

These compounds move at characteristic rates since the distribution coefficient between immiscible solvents is a fundamental property of a pure substance. After drying, the row of spots thus obtained is further separated by allowing a different solvent to flow through the paper at right angles to the first direction. The adjacent edge of the paper is immersed in a butanol-propionic acid-water solvent which slowly flows past the row of spots. The result is a map of spots in which each substance has a characteristic location on the paper.

The detection of these spots (they are all colorless) presented a problem. The originators of paper chromatography used it to separate amino acids for which there is a sensitive color test. The paper could be sprayed with ninhydrin reagent to give a purple spot where each amino acid was located. Compounds which are radioactive can be readily detected by scanning the paper with a Geiger tube. Better yet, a sheet of X-ray film is exposed to the paper to give a radioautograph of the paper chromatogram. This "radiogram" shows where each radioactive component of the original extract is located as well as the relative amount of its radioactivity. Such a radiogram (Fig. 2), reveals the large number of compounds that a plant can synthesize in ninety seconds. At least fifty spots can be detected on the original film.

To make this method useful it was essential to be able to read this "handwriting on the wall" and know what radioactive compounds caused the spots on the film. Only then would the radiogram serve as a picture of the chemical operations of the plant. To label the radioactive spots was a slow problem, but once done it could be applied in any number of experiments.

By comparing the radioactive spots recorded on the radiogram with the purple spots obtained by spraying the paper with ninhydrin it could be seen that the amino acids, alanine, serine, and aspartic acid were radioactive while the others were not. Since $C^{14}O_2$ had been converted to them in ninety seconds, these three amino acids were therefore closely related to photosynthesis. The major radioactive components, lying in the lower right hand area near the origin, were identified as phosphorus-containing compounds. Instead of labeled CO_2, radioactive phosphate (P^{32}) was given to plants during photosynthesis with ordinary carbon dioxide. The radiogram of the extract of these plants had black areas near the origin which corresponded exactly to those of the C^{14} radiograms.

Figure 3.

RADIOGRAM showing that the plant can synthesize only a few compounds in five seconds.

Phospho-sugars have long been known to occur in plants and were known intermediates in the breakdown of sugars by animal tissues and by yeasts. It appeared that plants were using processes for the reduction of carbon to sugars similar to those animals use for oxidation of carbohydrates to carbon dioxide. Several of these phosphorylated intermediates in sugar synthesis have been identified. They are not substances unique in photosynthesis but occur in reactions performed by all living things.

When a considerable number of the photosynthesis intermediates were identified it was possible to apply the method to determine the path of carbon in photosynthesis. If a plant, photosynthesizing in ordinary carbon dioxide, is given labeled $C^{14}O_2$ all the compounds into which the C^{14} is incorporated become radioactive. By killing the plant rapidly and examing the radiogram of the products one sees how far the $C^{14}O_2$ has proceeded on its path to sugar. By making the time between feeding the $C^{14}O_2$ and killing the plant shorter and shorter one sees fewer and fewer compounds in the radiograms.

Fig. 3 is a radiogram which shows that the plant has had time to make only two or three compounds in five seconds. These should include the very first products of carbon dioxide fixation. Since they are the two isomeric phosphoglyceric acids we feel that phosphoglyceric acid is the first stable intermediate of photosynthesis. In five seconds over 95% of its radioactive carbon is in the carboxyl group. Hence CO_2 must add to some two carbon compound to give phosphoglyceric acid labeled in the carboxyl group. As time goes on more and more radioactivity appears in the other carbon atoms of the molecule.

The first sugar (hexose) which is formed during such experiments has radioactivity in the middle pair (3, 4) of carbon atoms. Later, activity appears in the adjacent carbon atoms and last in the end carbons of the six carbon molecule. Sucrose, the first free (unphosphorylated) sugar to be formed in plants, contains both glucose and fructose. It was found that the sucrose synthesized in thirty seconds was more radioactive in

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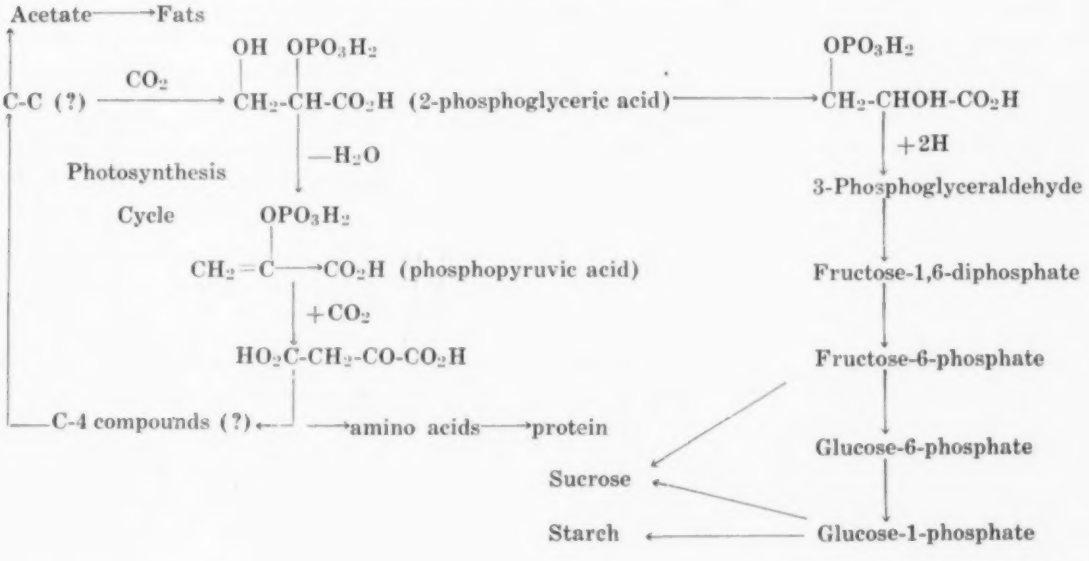
Probable Sequence in Photosynthesis



School-Made Motion Pictures for Science Teaching

● By **Zachariah Subarsky, M.S.**, *(Columbia University)*
CHAIRMAN, DEPARTMENT OF BIOLOGY, BRONX HIGH SCHOOL OF SCIENCE, NEW YORK CITY

The skill of amateur motion picture photographers can be put to good use in making movies for classroom instruction. Mr. Subarsky here describes two successful films made at the Bronx High School of Science. His high estimate of their value should stimulate other teachers to experiment in this field.

He desires to acknowledge the technical assistance of Mr. Theodore Benjamin, formerly of the Bronx High School of Science, in preparing the frog dissection film. Students in the Histology and Photography Squads assisted in making the histology picture.

●

To provide experiences calculated to influence the physical, mental, and spiritual growth of children—that is the function of the teacher. There is no absolutely equivalent substitute for direct, first-hand experience. That is why, from earliest times, planned travel was regarded as one of the most effective educational influences; that is also why the field trip and the laboratory are considered so vital to good science teaching.

Considerations of expediency have severely limited the incorporation of field trips into the program of science teaching in most schools. The lack of equipment or the shortage of time has likewise precluded some kinds of laboratory experiences. Through the use of school-made motion pictures *some* of these deficiencies can be made good. Two such motion pictures will be described: a film that contracts time, and a film that contracts space.

1. How Muscle-Tissue Slides Are Prepared

Permanent, "prepared," microscope slides are used even in the most elementary courses in biology. How many students ever really comprehend the relationship between what they observe under the microscope and the organism from which the material on the slide came? How many students have an appreciation of the time, labor, and skill that goes into the preparation of a good tissue slide? To develop such understanding and appreciation, we have prepared a motion picture in which the student sees a muscle removed from a frog. He sees how the muscle is fixed, dehydrated, impregnated with paraffin, and sectioned with a microtome. He sees the "slices" mounted and spread and the paraffin removed. He sees the sections run down to water, stained, dehydrated once again, and preserved in balsam. This processing, which ordinarily takes several days, the students experience in fifteen minutes. Here we see how the motion picture, by contracting time, enables a teacher to provide an experience not otherwise possible. Incidentally, some of our students have become so intrigued with the process of preparing slides as seen in the movie, that they have been moved to apply for membership in our histology squad.

2. Laboratory Directions for the Dissection of the Frog

In the biology laboratory we point out to our students the difference between dissection and butchery. But without adequate instruction students, at best, are butchers. Conventionally, directions for the dissection of the frog are given orally, or in mimeograph instructions, or in the form of an actual demonstration. In our experience, oral instruction is inadequate. Mimeographed directions have little meaning to an inexperienced student. Actual demonstration is most effective. But here the teacher of a large class—say thirty or forty—is confronted with difficulties. It is impossible to bring that many students close enough to the dissection. Even if this *were* possible, students would find it difficult to retain all the steps in the dissection. To demonstrate one step at a time would involve calling the class up to the demonstration table fifteen or twenty times during a laboratory period.

To overcome these difficulties we have prepared a motion picture designed to give directions to students for the dissection of the frog. The directions are given one step at a time—"lay out the instruments," "pin down the frog," "make an incision in the skin," "cut the abdominal wall," "fold back and pin down the abdominal wall," etc.

Each direction (scene) in the film is separated by a "leader" so as to enable the teacher to stop the film and have the class proceed to carry out the step in the dissection before witnessing the next step. The scenes on the screen are so large that every student, no matter where in the room he sits, practically has his nose in the dissection without leaving his seat. Over several years, teachers and students who have used the film have expressed great satisfaction with it.

Both the films described above were produced, as all good teaching films should be produced, to fill a teaching need. A teaching film should be a tool in the hands of a good teacher, not a substitute for a good teacher. A teaching film should amplify and enrich real experience, not substitute for real experience where real experience can be provided. There are any number of learning situations in the science classroom and the science laboratory where such motion-picture teaching tools are needed. Two films have been described here to encourage *other* teachers to "make their own." ●

The Religious Responsibilities of Scientists

● **By Richard M. Field, Ph.D.,** (*Harvard University*)

CHAIRMAN, COMMITTEE ON THE SOCIAL VALUE OF THE EARTH SCIENCES (1945-1948), AND CHAIRMAN, COMMISSION ON CONTINENTAL AND OCEANIC STRUCTURE (1926-1948), INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS, SOUTH DUXBURY, MASSACHUSETTS.

This is a stimulating article. Have scientists a special responsibility to humanity? Should they dictate what use is to be made of their inventions and discoveries? Are our most important international problems the result of an unequal distribution of natural resources? Will the future rôle of the scientist be increasingly social? Is it true that Man has only Man to conquer? Do we underrate the power of thought?

The distinguished writer of this article asks and answers many questions. Regardless of whether or not you always agree with him or those he quotes, your thought will be challenged.

●

What is Science? The Christian Scientists define un-Christian Science as Natural Science, meaning, perhaps, that there is both a scientific and an unscientific approach to Religion!

In the estimation of the Chairman of the Committee on the Social Value of the Earth Sciences, International Union of Geodesy and Geophysics, the most significant results, to date, of the work of its sub-committee on Physics, Metaphysics and Religion are as follows:

1. The particular religious creed of any scientist, including those not classified as Christians, in no way interferes with his scientific attainments, according to his peers.

2. The particular nationality of any scientist, including those constantly reclassified as national or ideological enemies, in no way interferes with his scientific attainments, according to his peers.

3. All true scientists are as "human" and emotional as other professional and non-professional human beings, including clergymen, actors, painters, sculptors, musicians and poets. Because the fundamental laws of their profession require scientists to control their emotions or personal desires during their labors, they may be when "on vacation" as emotional, irrational, pedantic, vulgar, profane and bigoted as any other human being.

4. The progress-rate of scientific research and its application, including medicine, was greatly accelerated during the two world wars. The unlimited resources available to even mediocre scientists when their skills are required for destructive purposes has, as yet, never been equalled for constructive purposes.

5. The increasing administrative overhead of scientific coördination has already begun to tarnish, if not dull, the best efforts of the best scientists. The deleterious effects of over-zealous administrative controls are:

(*a*) an increasing emotional release of propaganda by means of the press and radio;
(*b*) an increasing pressure by schools, colleges and universities on their personnel primarily for economic reasons and the consequent publicity;
(*c*) an increasing pressure by religious institutions on their personnel for economic reasons and the consequent publicity;
(*d*) an increasing, but quite natural, lack of real personal interest by the public in national or international affairs other than when each item is sensational or may affect them or their particular organization.

The future rôle of science will be increasingly social in that science and human affairs have become inseparable. Popular science may no longer be defined only in terms of the marvels of inventions and new gadgets; popular science must also include the relation of science to society, and the sincere attempt by scientists to see that this information is available not only to a few favored individuals or groups, but to all elements of society through whose coöperative efforts their developed environments have been created.

After Materialism—What? by Sir Richard Tute, was published in 1945. Sir Richard happens to be one of the very few deeply religious men who have walked and talked with the forefathers of modern science such as J. J. Thomson, Ernest Rutherford, and James Jeans. Sir Richard concludes the last chapter, 'The Loom of a Plan" with these lines:

> "Everything is super-physical, and remains super-physical after it has acquired the additional attribute of being perceptible. You and I are super-physical here and now. When death supervenes we will continue to be what we are, while disappearing from the physical stage. What we will encounter when we come face to face with the naked forces of four dimensional reality is unknown to us, except in mystic reports . . . . . The experience will presumably vary with the desert of the subject. He will get what he has earned . . . . . I recommend the fact to the notice of the gentry who are now amusing themselves with laying waste the world."

In May, 1949, Dr. John Dillenberger of Princeton University's Department of Religion, under the title of "Christianity, Science and Truth," comes to the following conclusion: "Only when science and religion are made to complement, but not encroach upon, each other, can it be said that men have adopted a sane and consistent 'settlement'."

One month previous to Dr. Dillenberger's pronouncement I had the great privilege of attending the Massachusetts Institute of Technology's Convocation Panel on "Science, Materialism and the Human Spirit," not as a delegate of any American institution but as a past, present and future student of M.I.T., and official observer for the CSVES, IUGG. I have on my desk the complete typescript of this most unusual Convocation;

unusual in that it was planned and executed by a great school of engineering, not by a liberal arts college or university. When all the panel discussions are published in full they will, in my estimation, contribute as much, or more, to the full realization of the *scientist's responsibility* to humanity than all the publicity either by such international adjuncts to the United Nations as UNESCO, or the over-advertising by the atomic physicists of any country, including the United States of America.

To quote only from Dr. Julius J. S. Bixler:

> "The members of this panel have been asked whether there is any basis for continued common action at the highest spiritual level. For me there is only one answer. We have such a basis, and to see what it is we have only to draw the implications of what we are already doing. The fact that we have not done what we know is right does not, after all, prove that what we believe to be right is wrong.
>
> "It is clear that we [institutions of learning] have failed to live up to what we profess. It is also clear that we are on the point of losing our nerve. Today we stand in special danger of underrating thought and its power. What we call 'reason' and 'mind' are on the defensive. The constant attack on the so-called 'liberal-optimist' view is one evidence. In many areas of life the arts of persuasion are yielding to the insistent pressures of violent compulsion as a means of deciding issues. The cult of the 'daemonic' in contemporary theology, the use of distortion in modern art, and the retreat into the unconscious in present-day literature all indicate a growing suspicion that men cannot face up to and solve the problems of life today. Inevitably science is summoned before the bar of judgment and is labeled a false Messiah which has not brought the salvation it promised . . . . . Instead of losing faith in science should we not, then, recover its religious implications? . . . . . According to Professor Whitehead: The increasing departmentalization of universities during the past hundred years, however necessary for administrative purposes, has tended to trivialize the mentality of the teaching profession . . . . . The abuse of our knowledge for acquisitive and competitive purposes stands out more clearly as the dangerous evil it is."

In his delightful and remarkable essay on "Pictorial Forms of Nuclear Energy," Charles Bittinger wrote as follows:

> "In preparing for the work at Bikini we were confronted with an unusual set of artistic problems, chief of which was the novelty of the subject. The problem was almost the reverse of the usual modern one. There was no need to develop a new method for producing a deeper insight or wider comprehension of the subject, the problem which has—and still does—hold the attention of 'Modernists.' It might be that all of the methods, or none of them, would be used. *The problem was handling an unknown, and very temperamental, model.*"

In *America*, a Catholic Review of the Week, April 23, 1949, Vol. 81, Number 3, page 108, are two editorials entitled "Operation Vanity," and "Operation Violence." Some 25 years of experience on national and international commissions and committees have constantly brought to my attention how Operation Vanity eventually leads to Operation Violence; or those who seek publicity eventually become only notorious—"the appeal to a sublimated type of vanity." The increasing notoriety of so many of the so-called intellectuals in the United States of America is not to be excused by the menance of atomic fission, at home or abroad.

It is true that at the last moment Russia refused to attend the Eighth Assembly of the International Union of Geodesy and Geophysics held at Oslo, Norway, one year ago. Russia, and especially the Russian Academy, may have been acting reasonably according to protocol, but her behavior made it all the more difficult for the Committee on the Social Value of the Earth Sciences to which thirty-four nations adhere, and there is no reason to doubt that Russia did this deliberately. But no scientist has the right to dub himself as Christian Scientist, Natural Scientist, Political Scientist or Social Scientist so long as he consciously or unconsciously, uses the suffix of his title merely to dignify the prefix.

"Few geniuses, history seems to show, are quite satisfied with the confines of their own preeminence. A surprising number secretly long to achieve something else for which, by training and temperament, they are quite unfitted. In sharp contrast with this concept of [scientific] responsibility is the picture of some American scientists. Our wonder grows when we see them still cultivating their professional prestige while placing it at the service of an [any] agency [national or international] which, they will one day discover, holds them in complete contempt. The way to put down disorder is to launch needed social reforms everywhere, since you can't cure Communism [or any conflict between *isms*] by shooting it down; and to strengthen, by United States and Western European aid, the sound elements in newly formed native governments. This is a tough program to carry through, but not so tough as a world of chaos, hatred and [*ism*-inspired] violence."

As Chairman of the Commission on Continental and Oceanic Structure and the CSVES, IUGG, at the Oslo Assembly of the IUGG and at the XVIII International Geological Congress immediately following, I, both in conference and publicly, expressed my opinion as registered in my memorandum to the Secretary of the Bureau. I will only requote that portion of the memorandum which was not directly quoted under the title "Operation Vanity" in *America*.

> "The best possible cooperation of all scientists, whether they consider their work either Fundamental or Applied Science, is absolutely essential to the proper conduct of human affairs regardless of race, creed, religion, economics, politics or ideology. This, I know, is easy to say even if those who practice Theology, no matter what their creed, may disagree with me. Or those who practice Economics, no matter what their greed, may disagree with me. Or those who practice Politics, no matter what their motive, may disagree with me. But no scientist has the right to dub himself as such unless he always wishes to discover, so far as possible, the truth. No matter, how personally, racially, economically, politically, religiously or ideologically that truth may be objectionable to him.

(Continued on Page 140)

Detective Work on Deficiencies

● By **Malcolm H. McVickar, Ph.D.,** (*Ohio State University*)
CHIEF AGRONOMIST, THE NATIONAL FERTILIZER ASSOCIATION, WASHINGTON, D. C.

Plants as well as animals must be properly fed if they are to grow and flourish. The plant hunger signs which are so plain to one who understands them were once thought to be symptoms of disease.

Soil deficiencies can be corrected. By properly interpreting the plants' symptoms of malnutrition farmers can tell what must be added to the land to nourish the crops so as to furnish food that will develop healthy livestock and provide health and strength for people.

Dr. McVickar, who was formerly on the staff of the Virginia Polytechnic Institute, tells an interesting story.

●

Deficient nutrition of plants and animals is in evidence throughout our Nation. These deficiencies, when they appear, are signs—danger signals telling that the resources in our soils are becoming exhausted. Even when there is no acute or obvious deficiency, the supply of an essential element may be so limited that the plant or animal will suffer.

Plants do not speak our language but they do talk through deficiency symptoms. Anyone who takes the trouble to study the symptoms of malnutrition will be in position, in many cases, to correct the difficulties. A working knowledge of deficiency symptoms, the hunger signs, will serve well the horticulturist, the wheat grower, the general farmer, and also the livestock producer.

To the last group, plant nutrition is extremely important since livestock depend upon plants for feed, and animals in general are as poor or as healthy as the plants they eat. The Yearbook of the United States Department of Agriculture for 1939 states:

> "In general the amount of any fertilizing element in the soil is reflected in the chemical composition of the plant grown on the soil and also in the physical condition of the animals grazed on these plants. Where deficiency in calcium, nitrogen, potash or phosphorus occurs in the soil and when increased growth results from the application of one of these elements, the increased growth is usually correlated with an increase in the plant of the particular element applied to the soil."

Soil deficiencies and consequent plant hunger problems have confronted us only in recent years. When the white man first came to America, he found a continent of many different kinds of soil. The prairie lands covered with heavy grass were among the best lands in the world for a productive agriculture. Of course, there were other lands not so fertile, soils where only scrub oaks and pines would grow. Likewise, there were desert lands where the rainfall was too low for an abundant plant growth. But all in all, man's blessings in the earth were rich ones.

It is high time to assess the present status of these blessings. The report is not too favorable. As our trees have been cut down and as our grass lands have been plowed under, erosion has taken its toll. Quite as serious, our farmers have grown crop after crop on the same land without returning anything to the soil. As a result, many of our soils became poorer and poorer, and livestock were forced to feed on plants of lower nutrient content.

Early Findings

The dangers in such practices were noted early in other countries. In 1811, William Aiton associated the kind of soil with the thrift of cattle in southwestern Scotland. He said, "The soil, climate and mode of feeding and treatment so profoundly affect the size and quality of cattle that it becomes impossible to raise them above what they can support." In 1831 Hogg wrote of an anemia called "pining" among sheep on the northern slopes of the Cheviot Hills on the Scottish Border and observed: "There is only one effective cure known in this country, which is a change of pasture to one of more succulent herbage . . . . . If the sheep are laid on clover or limed ground, the cure is the quicker."

According to Sir John Orr in *Minerals in Pastures*, chemical analyses of German pastures were suggested

WHEAT AT THE LEFT. Fertilizer increases yield and hastens maturity. Barley in head (center) received fertilizer at planting time.

as early as 1873 for ascertaining what fertilizer should be applied in different districts to obtain high-quality hay. Orr himself followed this statement by emphasizing that there may be nutritional deficiencies of grass in many parts of the world which, though not so marked as to cause gross signs of disease, yet limit the rate of growth and of productivity; and may adversely affect the constitution of the animal, rendering it more susceptible to some diseases of bacterial origin. "Apart from the question of bulk, the nutrient value of the pasture depends on the extent to which it contains all the essential food constituents in the amounts and proportions required by the animals."

The Toll on Our Soils

Modern science has further developed our knowledge of this subject. We are aware that good crops must have their choice of elements that make up the earth, its atmosphere, and its waters. Animals too must be able to get the elements they need for growth and well being, and large quantities of raw materials are required to make them available.

Scientists have found, for example, that 100 bushels of corn growing on 1 acre require over 5 million pounds of raw materials.

Water. Five million pounds. That would be 21 inches deep over the entire acre. The hydrogen and oxygen in water are both important as plant foods. In addition, the water also acts as a conveyor of other plant foods in the soil and through the plant tissue.

Oxygen. Six thousand eight hundred pounds. Sixty-eight hundred-pound cylinders of oxygen.

Carbon. Fifty-two hundred pounds. As much carbon as there is in 4 tons of coal.

Nitrogen. A hundred and sixty pounds. That is the amount of nitrogen in 16 tons of good manure.

Potassium. A hundred and twenty-five pounds. That's 208 pounds of muriate of potash.

Phosphorus. Forty pounds. The equivalent of 460 pounds of 20 per cent superphosphate.

BORON DEFICIENCY IN BEET
LEFT, Minus Boron
RIGHT, Complete

Magnesium. Fifty pounds, as much as there is in 500 pounds of Epsom salt.

Calcium. Fifty pounds, as much as in 125 pounds of limestone.

All these raw materials must be in the soil, air and water where a good corn crop grows. All these are needed to set the stage for the production of 100 bushels of corn on an acre. Total them up and you have 5,012,425 pounds of raw materials — almost a thousand times the weight of the corn itself. From these raw materials, most of which come from the soil, are drawn the elements for growing a good corn crop that will wave its healthy tassels against the sky.

Some Typical Deficiencies in Plants

If the needed elements are not available, trouble will result. Corn plants that have been starved for nitrogen will turn yellowish green and be stunted in growth. When corn is hungry for nitrogen its lower leaves "fire" — turn yellow — and finally die. Down along the midrib the yellow color shows plainly when the corn has been deprived of nitrogen. The yellow color, the hunger sign, showed up first at the tip, and then spread right down to the ground.

Tomatoes that lack phosphorus have reddish purple stems and veins under the leaflets.

Alfalfa that lacks boron has terminal leaves that turn yellow — and plants that are dwarfed and curly.

Ladino clover lacking potash shows yellowish spots around the margins of the leaf. Then the entire margin becomes yellow and the leaf finally dies.

Cotton plants hungry for magnesium are rather easy to identify. They have purplish red to red leaves in the later stages with characteristic green viens. The soil they grow in lacks magnesium, and the cotton plant tells in its leaves, the story of its hunger.

Many of these hunger signs were once thought to be symptoms of disease. Now we know they mean starvation wherever they appear—on the leaf, perhaps on the stalk, maybe in the roots.

Phosphorus Deficiency

Phosphorus deficiency is frequently observed in both plants and animals. About 25 years ago, it was observed in farm cattle in Wisconsin and Minnesota. The symptoms were stiffness of joints, harshness of coat, dull eyes, unthrifty condition, and perverted appetite which resulted in bone chewing. The almost immediate recovery of severely affected animals through the use of phosphorus supplements or by feeding hay grown on better soil stimulated much research in other areas. In Michigan and elsewhere, it has been shown that farm livestock may actually be suffering from a lack of adequate mineral matter as measured by blood analysis and yet show no external evidence of deficiency. Because of the apparently large number of borderline cases of mineral deficiency, it becomes more important to supply animals with adequate mineral matter.

(Continued on Page 149)

The Nature of Space

● **By Robert Cameron Colwell, Ph.D.,** *(Princeton University)*
HEAD, DEPARTMENT OF PHYSICS, WEST VIRGINIA UNIVERSITY, MORGANTOWN, WEST VIRGINIA

This brief, thought-provoking article is a rewrite in non-technical language of an address given recently before the American Association of Physics Teachers, Western Pennsylvania Section. It requires careful reading.

Dr. Colwell points out that the general laws of physics are based upon experiment and observation. We need not know the reasons for the laws provided we know how they act. Einstein's equations for the Michelson-Morley experiment explain how we go from one system to another, but they do not give the reason. There are several interpretations of the equations. An acceptable theory of space should reconcile all divergent views. The most likely foundation for such a theory is suggested.

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Any satisfactory theory of space should give an explanation of all the fundamental laws of physics. The first set of laws to be examined are Newton's three laws of mechanics. The first states that a body at rest remains at rest and a body in motion continues in motion with uniform speed in a straight line unless acted upon by some force. The second law as given by Newton reads: The rate of change of momentum is proportional to the impressed force and acts in the direction of that force. The third law covers the case of action and reaction or force and counterforce. When these laws are expressed in mathematical language, they may be used to calculate all mechanical motions. Nowhere however do they explain why bodies have inertia, or why force and changing momentum are proportional, or why action is equal to reaction. In other words we know in mechanics how the motions take place but not why they take place. The same thing is true of gravitational attraction: the law of attraction is known but not the reason for the law. Coulomb's laws of electric (and magnetic) attraction and repulsion are based upon experiments. Maxwell's laws of wave motion are derived from the observations and experiments of Faraday. The Einstein equations are the mathematical expressions of the results of the Michelson-Morley experiments. These showed that regardless of the velocity *(v)* of the measuring observer the velocity of light is always *(c)*.

Hence all our physical laws are founded upon experiments or observations. They tell us "how" nature works but not "why" it works. If a physicist is interested only in "how" nature works, he will be satisfied with the equations and will not care about the "why." If however he becomes a natural philosopher and seeks to know the reason for the equations, he will necessarily make some hypotheses regarding the space through which all mechanical, electrical and gravitational forces act. He can assume that space is mere emptiness and give qualities to this space such as the power to contract a body in motion through it and to change the rate of a clock. On the other hand he can fill space with Faraday tubes and endow them with certain properties. In either case he will run into difficulties.

We shall look first at the difficulties of those who postulate an empty space possessing qualities which explain the Michelson-Morley experiment. The fundamental law of this space is given by Einstein in the words "the measured velocity of light is always c, regardless of the velocity v of the measuring observer." I believe that this statement is true, but it should not be further resolved into the statement that it is true because bodies contract in the direction of their motion and that clocks vary their rates with varying velocity. If the second assumption is added to Einstein's original declaration, misunderstandings immediately arise.

For instance, Epstein[1] says

> "It is the opinion of the present writer that any presentation of the theory of relativity intended for wider circles should particularly emphasize its operational aspect. The occasion for the foregoing remarks is the appearance of a new popular booklet by Professor Herbert Dingle which not only neglects to bring out the operational tendencies of relativity but flatly denies them by implication. The rate of a clock is changed when the latter is set in motion with constant velocity . . . . . .
>
> "It will be well to discuss another point in Dingle's book which is sure to be confusing to the reader, his repeated insistence that the relativistic contraction of solid bodies is not real but due only to the mental attitude of the observer."

Dingle[2] makes this rejoinder

> "I maintained that the whole modification of classical physics required by the special theory of relativity was contained in the contraction of lengths by the factor
>
> $$k = (1 - v^2/c^2)^{1/2} \quad \ldots\ldots \quad (1)$$
>
> "All the other modifications—the Lorentz formulas, the 'dilatation of time,' the change of mass with velocity and so forth—being logical consequences of this single change and the traditional definitions of physics. He (Epstein) attributes to me 'a repeated insistence that the relativistic contraction of solid bodies is not real but due only to the mental attitude of the observer.' I cannot find that I used the words 'not real': I said rather that 'no physical change' occurs in the bodies. He (Epstein) then goes on to argue that the Lorentz contraction is real in the ordinary sense of the word. The contraction is as 'real' as the velocity which causes it, and since the theory of relativity allows us to assign to any single body whatever velocity less than c we please, it allows us to assign to it whatever contraction we please. The relative velocity of two bodies is 'real,' but the contraction which arises from that may be assigned to whichever body we choose."

A third point of view is taken by Lindsay and Margenau[3] as shown by the following statement:

> "The natural tendency of one who feels that he has a deep-seated intuition of the fundamentals of space and time is to ask at this point: is the moving rod REALLY shorter? Does the moving clock actually run more slowly? And does it not seem paradoxical that if a clock in S' appears to run slow from the standpoint of S, the same clock in S appears to run slow from the standpoint of S'? To those who have grasped the view of modern physics discussed in the early chapter, such questions will appear distinctly irrelevant. Space and time are indeed fundamental categories in which physical theories are constructed. Nevertheless we cannot accept the view that these categories are given once for all to human minds by direct intuition or otherwise. Different types of space and time are logically possible, and if the common lay view proves inconvenient in the development of physics we need have no scruple in adopting a different one —there arises no question as to the *real* length of the rod."

So far we have discussed the opinions of several physicists who base the Einstein equations upon the nature of empty space. Let us now examine the theories of several others who believe that space is filled with an ether of some kind. First of all, it is well known that Faraday originated the idea of lines of force filling all space. Maxwell used these tubes in developing his electromagnetic theory.

Millikan[4] writes that by 1900 the ether theory had become apparently impregnably intrenched. In 1902 it met with some opposition of a rather ill-considered sort from a group of extreme advocates of the relativity theory, but this theory has no bearing whatever upon the existence or non-existence of an ether. The ether was called into being to furnish a carrier for electromagnetic waves *in vacuo*, and this has never been questioned by anyone.

J. J. Thomson[5] believed in an ether made up of tubes which Faraday had endowed with certain physical properties, such as a tendency to contract along their length and also to repel one another. In this way Faraday had accounted for the repulsion and attraction of electric and magnetic charges. Thomson added the property of inertia to these tubes and was then able to show that the mass of a body, if regarded as entirely due to electrical charges (or rather to Faraday tubes attached to electric charges), varied with the velocity v in exactly the same way as the mass varies in the Einstein theory. Thomson's theory and Einstein's theory both give the well known equation $m = m_o/\sqrt{1-v^2/c^2}$. Einstein has also developed the equation $E = mc^2$ from classical conditions alone (cf. Lindsay and Margenau, Page 351). To Thomson, the ether outside the charged body is the seat of all mass, momentum and energy. Space[6], if it is to be of any use in physics, cannot be a void.

There are then four theories of space which must be examined and accepted or rejected according to the evidence. First, the theory that space is mere emptiness or void. This theory has been rejected by such physicists as Descartes, Newton, Bernouilli, Huygens, Young, Faraday, Maxwell, Kelvin, J. J. Thomson and R. A. Millikan.

Second, that space acts in such a way as to make valid the Larmor, Lorentz and Einstein equations which are the basis of relativity. I believe that these equations are true and are invaluable in modern physical theory. The point to be discussed is not whether they are true but rather the reason for their being true.

The third theory, founded upon the idea that all space is filled with a subtle quiescent fluid, which would act as an absolute system of reference for moving material bodies, was destroyed by the Michelson-Morley experiment.

The fourth theory of Faraday tubes in which the tubes themselves are attached to the moving bodies and so move to some extent along with the bodies, offers the main hope of a reconciliation between relativity and classical mechanics. In other words an ether must be devised which will satisfy the Einstein equations and will not act as an absolute reference base; it will most likely be founded upon Faraday's theory of electromagnetic tubes of force.

Summary

All the general laws of physics are based upon experiments and observation. Newton's laws of mechanics were determined by experiment; his law of gravitation by observation on the heavenly bodies. It is not necessary to know the reason for these laws provided we know how they act. In the same way, Einstein's equations for the Michelson-Morley experiment explain how we go from one system to another but they do not give the reason for these equations. If we attempt to explain these equations we immediately get into various interpretations. This is shown by the different statements of Epstein, Dingle, Lindsay and Margenau. Practically all physicists agree that space is not a void (mere emptiness)and that a proper theory of space would dispose of the difficulties. The only plenum which seems to fill the requirements is made up of electromagnetic tubes first proposed by Faraday and used later by Maxwell and J. J. Thomson. These tubes must act so as to satisfy the Einstein equations. ●

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Meaningful Applications of Trigonometry

• By Lyman M. Kells
DEPARTMENT OF MATHEMATICS, UNITED STATES NAVAL ACADEMY, ANNAPOLIS, MARYLAND

Trigonometry comes alive for students when some of its many applications to the physical sciences are brought to their attention. Interest is stirred, and clearer concepts are implanted in the mind of the learner.

Here are some suggestions for new and unusual problems based on the uses made of trigonometry by engineers and navigators and other scientists and professional workers.

This article is a condensation of a paper presented recently by Dr. Kells before The Council of the Teachers of Mathematics in America.

●

Trigonometry is a simple subject but it is alive with real applications in the physical sciences. Navigators, surveyors, engineers, astronomers, and practically all scientists use it constantly, and the simple applications made by them can be used as problems in the classroom.

In this paper an attempt will be made to suggest by means of brief statements and illustrative examples, general fields of applications usable in the classroom.

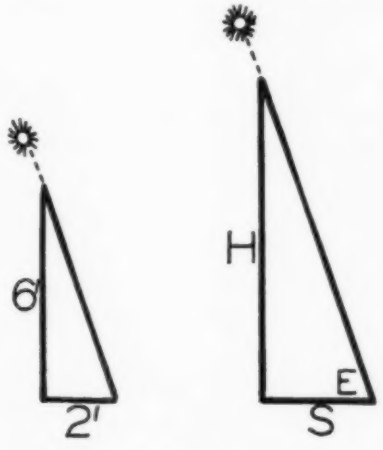


FIG. 1

Perhaps the best applications are those requiring heights and distances because they can be used without explaining abstruse concepts. A student sees at once that when a vertical pole (see Figure 1) casting a 2-foot shadow is 6 ft. high, a building casting a 25-foot shadow will be 75 ft. high, and in general, that the relation between height H, length of shadow S, and angle E of the sun's elevation is

$$H = S \tan E \qquad (1)$$

In most text books on trigonometry, there are numerous excellent problems relating to distances across swamps, heights of hills and buildings, and, in general, distances to and between inaccessible points. These are excellent, but, because they are well known to mathematics teachers, this paper will deal with rather unusual ones. The following problem is suggestive of problems relating to road making.

A railroad is to be laid along the arc of a circle so as to change direction by 68° (see Figure 2). The distance from the center of the curved piece to the point B, where tangents at its ends A and D meet, is to be 200 ft. An engineer computes: (a) the radius of the track; (b) the length AB of a tangent at end A; (c) the angle between AB and two successive 100 foot chords, the first passing through A. Find these quantities and show how the engineer would use them in locating points on the proposed curve.

From triangle BAC of Figure 2, we find radius R = 970 ft. AB = 650 ft. In Figure 2(a) angle BAE

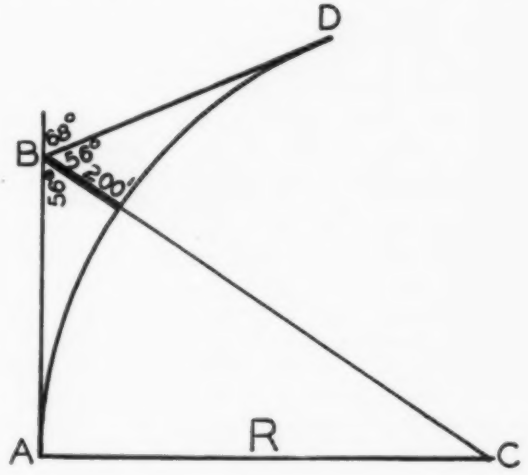


FIG. 2

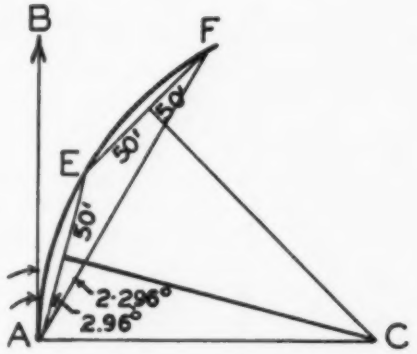


FIG. 2(a)

$= 2.96°$, and the angle between AB and AF is $2 \times 2.96° = 5.92°$. The engineer standing at A turns his transit through 2.96° from AB and by signals causes tapemen with a 100-foot tape to locate point E; he then uses the same procedure to locate point F on the required arc 100 ft. from E, and so on. The lengths AE and EF are not drawn to scale.

By changing the angle through which the road is to turn, and using other specifications, many varieties of problems can be obtained.

Railroad Curves and Earthwork by Frank Allen, S.B., McGraw-Hill Book Company, is good. Also books on surveying suggest a great variety of problems relating to construction.

Problems on piloting may be represented by the following:

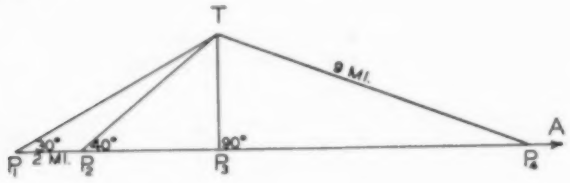


FIG. 3

At 10:00 A.M. the captain of a ship steaming at 12 knots in a direction P_1A (see Figure 3) observes a tower T bearing to port (left) 30° (angle $TP_1P_3 = 30°$), and 10 minutes later he finds that the tower T bears 40° to port. Find: (*a*) the distance from ship to tower at the time of the second observation; (*b*) the time when the ship will be nearest the tower and the corresponding least distance; (*c*) the time when the ship will be 9 miles from the tower and the bearing of the tower at this time.

By computations based on Figure 3 the following answers are found: (*a*) $P_2T = 5.76$ mi.; (*b*) 10 hrs. 32 min. A.M., least distance 3.70 mi. (*c*) 11 hrs. 13 min. A.M., bearing 155° 43′ to port.

The rather famous danger angle is illustrated by the following problem:

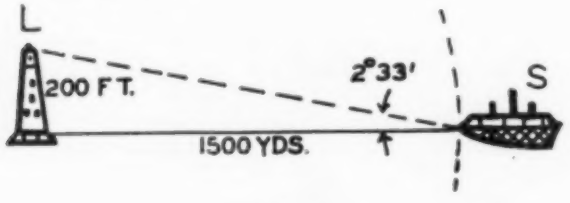


FIG. 4

The water within 1500 yards of a lighthouse (L) that rises 200 ft. above sea level is too shallow for navigation. Approximately what is the danger angle relative to the lighthouse?

The answer representing the angle subtended by the lighthouse at a ship (S) 1500 yards from the lighthouse is 2° 33′ (see Figure 4). If the angle subtended by the lighthouse at a ship is 2° 33′ or less, the ship is at a safe distance.

Among the more difficult problems should be mentioned the rather famous problem of computing one's position from angles subtended at an observer by three objects in known positions.

Many interesting problems on piloting are found in books of navigation. An excellent book for this purpose is *Nichol's Concise Guide, Vol I*, by Charles H. Brown, F.R.S.G.S. However, books on navigation, on piloting, and on maps present numerous situations forming the basis for trigonometric applications.

Vectors are of basic importance in the applications of mathematics. The concept of a vector and the sum of several vectors is easily grasped, and a countless number of problems can be stated and solved by using them. The following problems are only dimly suggestive of the great field.

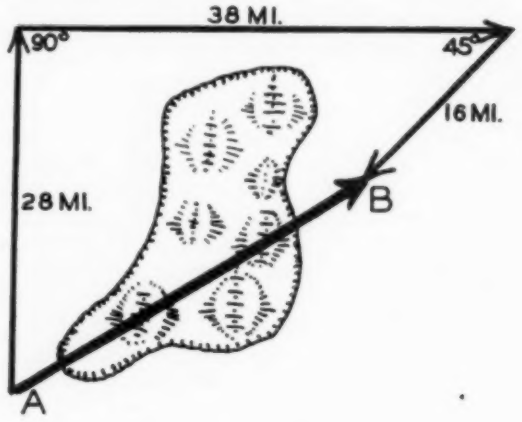


FIG. 5

The sum of three vectors one representing 28 mi. north, a second 38 miles east and a third 16 mi. southwest, specifies distance and direction from a town A to a town B on the opposite side of a mountain. Find the vector AB.

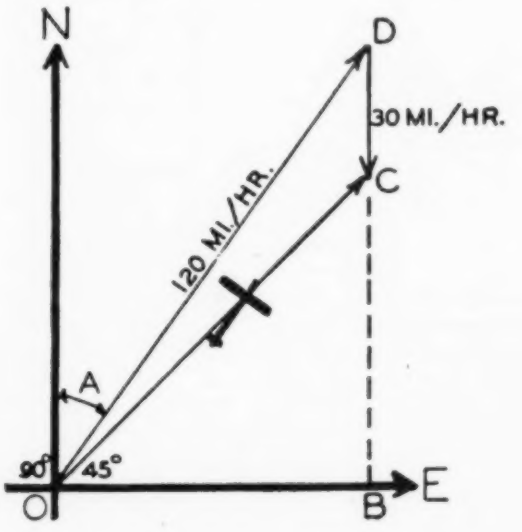


FIG. 6

The answer 31.5 mi. at N 57° 59′ E, found from Figure 5 gives the distance straight through the mountain from A to B.

The pilot of an airplane wishes to fly northeast in a wind blowing 30 mi./hr. south. If he makes 120 mi./hr. in still air, in what direction should he head his plane, and what will be his speed?

The answers obtained by solving Figure 6 are: angle $A = N$ 34° 49′ E, and 96.9 mi./hr.

A second boy pulls on a first one with a force of 40 lb. directed east and a third boy pulls on the first one with a force of 20 lb. directed northwest. If the first boy holds the other two, what force does the first boy exert and in what direction?

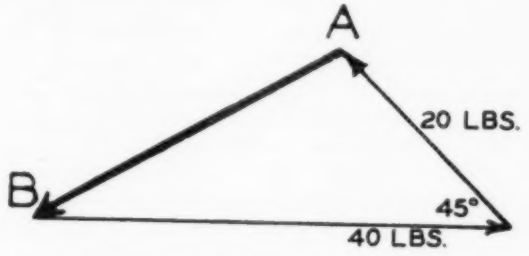


FIG. 7

Vector AB of Figure 7 represents the answer. It is 29.5 lb. at S 61° 20′ W.

More difficult problems are easily obtained by using more vectors and placing more conditions on them. Books on mechanics, on relative motion, and on vector analysis will suggest numerous types.

An outstanding reason for the importance of trigonometry in higher mathematics is its power of representing periodic phenomena. It is easy, in connection with the graphs of the trigonometric functions, to show that the function $y = A \sin kt$ represents a periodic motion with frequency $k/(2\pi)$, or $k/6.28$, cycles per second and amplitude A. Thus $e = 220 \sin 377t$ would represent an electromotive force of $377/6.28 = 60$ cycles per sec. and of amplitude 220 volts, and $i = 6 \sin 377t$ would represent an alternating current of amplitude 6 amperes and of period 60 cycles per second.

Now consider a wave motion represented by

$$y = A \sin 50.3t \sin 6.28t. \qquad (2)$$

Figure 8 (a) represents one period of

$$y_s = A \sin 6.28t, \qquad (3)$$

and Figure 8 (b) represents 8 periods of

$$y_f = A \sin 50.3t, \qquad (4)$$

each graph corresponding to a second of time. Observe that $|y_s| \leq |y|$, where the vertical bars represent *absolute value;* for $y = y_s \sin 50.3t$, and $|\sin 50.3t| \leq 1$. Also note that $|y_s| = |y|$ when $\sin 50.3t = \pm 1$. Hence the graph of (3) is inscribed in those of $y = \pm A \sin 6.28t$ as indicated in figure 8(c).

An outstanding feature shown in Figure 8(c) is a high frequency wave carrying one of low frequency. Imagine the frequency of the high frequency wave to be very high, far beyond detection by hearing, and the low frequency wave to be the comparatively slow sound

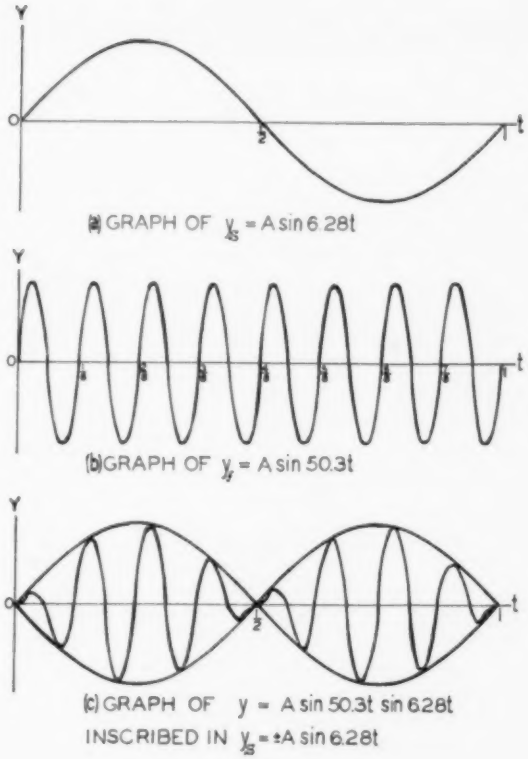


FIG. 8

wave. Then we perceive the idea, basic in radio transmission, of a sound wave, effective by itself only for short distances, carried to all parts of the earth by the powerful high frequency waves. We might think of the sound wave as saying to the high frequency wave, "you can travel great distances but are dumb; I can scarcely move but can talk; you carry me along and I will do the talking."

To get another interpretation of equation (2), change it to a sum, by the famous formulas for changing a product to a sum, and obtain

$$y = \frac{A}{2}[\cos (50.3 - 6.3)t - \cos (50.3 + 6.3)t]. \qquad (5)$$

From this it appears that the phenomenon represented by Figure 8(c) may be thought of as due to the combination of two waves of approximately the same frequency. This serves to explain the "beats" which one would hear in tuning his violin to a piano when the sounds coming from the instruments have almost the same pitch.

Physics texts and elementary books on sound, on electricity, and on radio furnish ideas for applications of trigonometry to wave motions.

Applications are important for several reasons. They plant powerful concepts, like vectors and waves, in the mind of the learner and these grow so that the student more easily grasps and understands their deep content when he meets them later on. Also applications are interesting. Students are impressed with the fact that

(Continued on Page 147)

Chemotherapy and Antibiotics

● By **Irving R. Hooper, Ph.D.,** *(University of Illinois)*
PROJECT LEADER, RESEARCH DEPARTMENT, BRISTOL LABORATORIES, INC., SYRACUSE, NEW YORK

This is a brief but authoritative discussion of antibiotics and their uses in medicine.

Here is presented useful information concerning the discovery, preparation, testing, and uses of these amazing new chemical agents. Penicillin, streptomycin, bacitracin, aureomycin, chloromycetin, and other useful antibiotics are discussed

Dr. Hooper directs attention to the value of antibiotics as research tools in medicine, organic and biochemistry, pharmacology and bacteriology, a point frequently overlooked.

●

The broad field of chemotherapy is based on the belief and demonstration of Ehrlich in 1904 that substances could be found which would attack a parasite or pathogenic organism without harming the infected host. That brilliant new concept has been enlarged since that time and today we have many chemical agents exhibiting this specificity which Ehrlich believed existed.

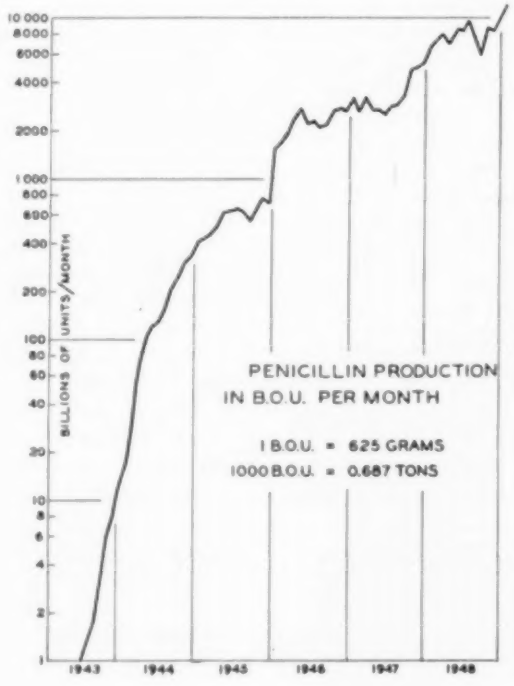
Among them are the antibiotics, which have been defined by Waksman, one of the pioneers in this field, as specific chemical substances produced by one organism which have injurious effects upon other organisms. In order to be of practical value as chemotherapeutic agents, they must also be relatively non-toxic to the infected organism, usually man.

Several varied classes of synthetic compounds have been studied as chemotherapeutic agents before and since the advent of antibiotics, for example, the early azo dyes, arsenicals, amidines, sulfonamides, sulfones, etc. However, the most varied and interesting materials studied are the antibiotics. Several useful or promising chemotherapeutic agents have come from this group of compounds, the most outstanding of which is undoubtedly penicillin. This amazing substance is virtually non-toxic to man and higher animals and yet amounts as small as sixty milligrams or less serve to effect clinical cures of diseases such as pneumonia.

In recent years the study of antibiotics has been a fascinating field of research. The uncertainties as to results, the varied types of compounds discovered, and the occasional discovery of a dramatically useful material have all combined to encourage a huge amount of research in this field. The early history of antibiosis is, however, rather sparse. Occasional reports of antagonism between microörganisms date back at least to Pasteur, who made some striking predictions as to the application of this phenomenon. Early but futile attempts were made to utilize such antagonism for therapeutic purposes.

However, the work of two separate groups of workers really laid the foundations of our modern studies in antibiotics. Every scientist is presumably familiar with Fleming's discovery in 1929 of an antibiotic-producing mold as a chance contaminant on an agar plate. The discovery remained unexploited, though, until about 1940 when Florey and Chain launched a persistent and resourceful effort to produce, isolate and identify the material responsible for the antibiotic action. After the demonstration of its therapeutic usefulness, an enormous amount of concentrated cooperative effort in England and the United States resulted in the practical production and wide-spread availability of this antibiotic.

Another investigation giving impetus to the study of antibiotics was the discovery by Dubos of tyrocidine and gramicidin in 1941. These antibiotics were isolated as the result of a carefully planned experiment. Dubos planned to isolate antagonistic organisms following their enrichment in a soil culture. By "feeding" pathogenic bacteria to a soil culture containing a varied and unknown group of soil organisms, he hoped to increase the relative proportion of organisms antagonistic to the pathogens. As a result of this work, tyrothricin, a mixture of the two antibiotics gramicidin and tyrocidine, was isolated.



Since these discoveries, the study of antibiotics has been a rapidly expanding field of research. In countless laboratories a continuing search for new antibiotics is being carried on. There are many reports in the literature of the isolation of antagonistic organisms. In many cases these have never

been fully studied. In other laboratories the investigations are pursued to a logical conclusion. The general course of such investigation is usually as follows. First, cultures of microörganisms such as bacteria, molds, and actinomycetes are tested for their ability to produce substances inhibiting the growth of a test organism. For such an examination, the culture under test is grown on an agar plate or in liquid culture and the antibiotics may be demonstrated in the solid media surrounding the culture or in the culture fluid. Next the organism is grown in larger quantities and methods are worked out for its extraction and isolation. It is then submitted to bacteriological and pharmacological testing to determine its range of effectiveness, its toxicity to animals, and its effectiveness in curing or preventing animal infections. If it passes these rigorous tests, and most substances do not, it is ready for cautious clinical trials. Usually, there is also a concurrent and continuing investigation of the chemical structure and possible synthesis of the active agent and its mechanism of action in the body. Also, practical methods for its large-scale production and isolation must be developed. As an indication of the rigorous restrictions imposed on an antibiotic, it is worth mentioning that of the two to three hundred antibiotics described more or less completely in the literature, less than ten are of interest as actual or potential chemotherapeutic agents today.

In still another way the study of antibiotics is an expanding field of endeavor. The border line fields of biochemistry and medicine have received a powerful impetus from the availability of a number of varied agents which exert a selectively toxic effect on microörganisms. Studies in cellular metabolism, enzyme reactions, genetics, and drug action, as well as many phases of organic chemistry, pharmacology and bacteriology have resulted from the interest in antibiotics. Further, the technology of large-scale aseptic fermentation and industrial extraction has undergone many advances. It is entirely possible that the future will find many of these studies resulting in fundamental knowledge as valuable as the practical results of the present medical applications.

There are several antibiotics currently in use as chemotherapeutic agents or which show promise of clinical usefulness. Tyrothricin, previously mentioned, is used commercially as a topical antibacterial agent. While very active, it cannot be used systematically because of its toxicity. It is produced by *Bacillus brevis* and is of great chemical interest since it is a polypeptide. It differs from the normal peptides and proteins of body tissue, however, in containing "unnatural" or D-amino acids, which are optical isomers of the normal building blocks of proteins and peptides. Its complete structure has not been determined.

The most impressive antibiotic studied to date is, of course, penicillin, elaborated by species of the *Penicillium* mold. An enormous amount of cooperative work in Great Britain and the United States was performed during the war in an attempt to determine its structure and effect a practical synthesis. The structure is known with a reasonable degree of certainty but as yet no practical synthesis has been achieved. Its usefulness in a wide range of infections is well known. It is nontoxic to humans for all practical purposes and yet inhibits many organisms in amounts as low as 0.02 micrograms per milliliter or less. It is active chiefly against the Gram-positive bacteria.

Streptomycin is another well-known antibiotic discovered in 1944 by Waksman. It is produced by the soil organism, *Streptomyces griseus*, and has a unique type of structure related to the carbohydrates. The elucidation of the complete structure, which contains several asymmetric carbon atoms, is an interesting chapter in the investigation of natural products. It is active against both Gram-negative and Gram-positive bacteria, including *Mycobacterium tuberculosis* and is used for many diseases not effectively treated with penicillin. Its greatest usefulness at present lies in the treatment of tuberculosis, for which it is the first truly effective chemotherapeutic agent.

Unfortunately, there are two drawbacks to the clinical use of streptomycin. Microörganisms rapidly and easily develop resistance to the effect of streptomycin so that even greatly increased levels of the drug fail to stop their growth. Unless a cure can be effected after a short course of treatment, usually a few weeks at most, further use of the drug is usually useless because of the presence of bacteria which can tolerate high streptomycin concentration. In a disease such as tuberculosis where treatment is necessarily prolonged, this is a serious drawback.

Another disadvantage in the use of streptomycin is its toxicity. Continued administration of the drug, especially in large doses, leads to impairment of nerve function. Varying degrees of lack of balance and loss of hearing may result. There are hopes that these difficulties may be overcome.

New antibiotics active against tuberculosis are being sought. They may be used either by themselves or in conjunction with streptomycin, to overcome the problem of development of bacterial resistance. The use of other compounds such as *para*-aminosalicylic acid and potassium iodide as adjuncts to streptomycin therapy has shown some effectiveness in animal experimentation. There is hope that the toxicity may be at least partially overcome by the use of dihydrostreptomycin, a chemically-modified streptomycin now available. This derivative is apparently less toxic but final conclusions must await long-continued clinical trials.

Several antibiotics of a polypeptide nature other than tyrothricin are currently under investigation in various laboratories. Bacitracin, discovered by Meleney, Johnson and Anker, is being produced commercially by several firms. Kidney toxicity from injected material has so far limited its use largely to topical applications. Clinical and laboratory investigations are underway to determine the relationship between toxicity and the presence of impurities. There is some reason for thinking that greater purification may eliminate some or all of the toxic effects. The range of activity of bacitracin is roughly similar to that of penicillin. It has

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The Story of Asbestos

● By M. V. Engelbach

MANAGER OF FIELD ENGINEERING, THE RUBEROID COMPANY; CHAIRMAN, SALES ENGINEERING COMMITTEE, ASBESTOS CEMENT PRODUCTS ASSOCIATION, NEW YORK, N. Y.

This story, filled with useful information about asbestos, its history, its remarkable qualities and its uses, was written by an expert who deals with this interesting material every day.

He tells how asbestos is mined, and how the fiber is extracted and made into shingles, building board, and industrial insulating materials. For some of its important uses there is no acceptable substitute.

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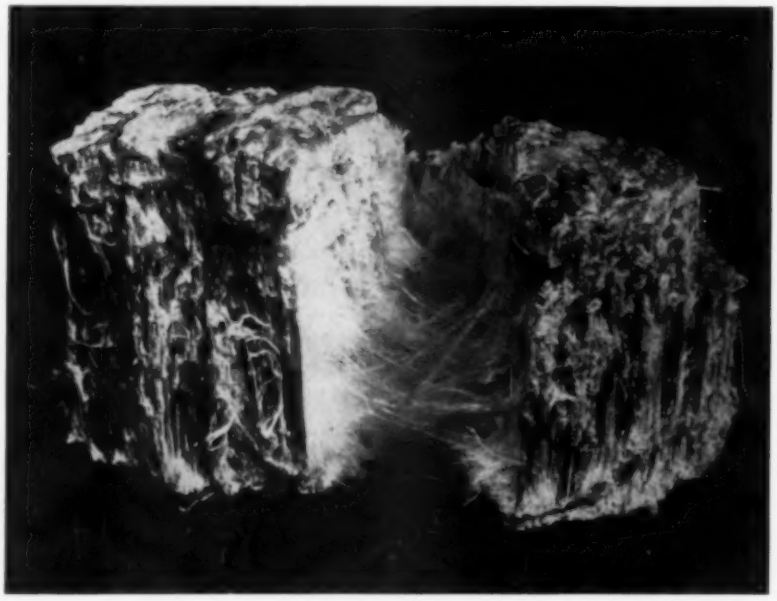
To many people the word asbestos means hardly more than a fireproof curtain in a theater. Yet, of all the gifts of Nature that serve mankind today none has a more fascinating history, and few have as many important uses.

So indispensable has asbestos become that we make almost constant use of it as we go about our daily business or pleasure.

In the asbestos brake linings and clutch facings that make possible the combined speed and safety of the modern automobile, in the fireproof asbestos-cement roof and siding shingles that today protect so many of our homes, and the corrugated asbestos-cement roofing and siding for factories, in materials that insulate steam and hot water pipes from heat and cold, in the asbestos board lined projection rooms that safeguard us at the "movies,"—in these and countless other ways, asbestos brings greatly increased safety and comfort.

Blast furnaces and steel mills, electric power stations and gas plants, railroads, ships, pipe-lines, and factories of almost every description, depend to a large degree on some asbestos product for their operation. From among these few examples alone it will be seen that asbestos is one of the important contributors to the machine age and our daily lives.

Contrasted with these outstanding uses are others as humble as pads for use on ironing boards, insulating jackets for hot water storage tanks, supports for cooking vessels on gas stoves, and materials for protecting wooden walls and floors from scorching by heaters or furnaces.



SECTION OF A VEIN of asbestos taken from the hard serpentine rock in which it is found.

What is Asbestos?

Asbestos has been graphically, although inaccurately described as a missing link between the mineral and vegetable kingdoms. It is, of course, a mineral, but one of the most extraordinary found in all nature. To the scientist it is a physical paradox, being both fibrous and crystalline. It is a rock that may be spun into yarn for the weaving of fireproof cloth; and in addition, as has been noted, it has almost countless other uses in the industrial world of today.

While asbestos fiber appears soft and downy, it is actually as dense and heavy as the massive serpentine rock in which it is found. Examined under the microscope, the smallest fiber visible to the naked eye is seen to be composed of a seemingly infinite number of smaller fibers. The fibers are not only flexible, but remarkably strong.

The secret of the great usefulness of asbestos lies in its unique combination of qualities—its fibrous structure, its fire resistance, its flexibility, its strength, its imperviousness to water, and its resistance to chemical action and decay.

Although the varities of asbestos are many, the type having the most extensive commercial use today is chrysotile asbestos. Ninety per cent of the materials known to the average person as asbestos materials contain asbestos fiber of this type, which, for that reason, is dealt with exclusively in this article. Chemically, chrysotile asbestos is a hydrous magnesium silicate, expressed by the formula

$H_3Mg_3Si_2O_9$.

Its Romantic History

The story of asbestos and its use is a romantic one.

In the year 450 B.C., Callimachus, a famous Greek sculptor and originator of the Corinthian column, was given the task of constructing a lamp to burn at the feet of Athena. The Greek geographer Strabo (63 B.C. to 24 A.D.) and the Greek historian Putarch (about 46 A.D.) mentioned these lamps, terming them "perpetual" because their wicks were made of asbestos fiber.

Charlemagne, King of the Franks from 768 to 814 A.D., is said to have averted one war by means of an asbestos tablecloth. When the savage hordes of Harun-al-Rashid, Caliph of Bagdad, threatened invasion of his empire, he called a peace conference. In the presence of the Caliph's ambassadors, he threw his tablecloth into the fire and when he drew it out and exhibited it to them unharmed, they went back home and advised Al-Rashid to avoid war with one who could summon to his aid the powers of magic.

About 400 years later, in 1250, Marco Polo, while traveling through Siberia, saw textiles that resisted fire. He was informed that they were made of the skins of salamanders, lizard-like animals that the ancients claimed could live in fire, but he traced the origin of this strange fabric to native asbestos-bearing rock and learned how its fibers were obtained and prepared.

SHINGLES. An aqueous mixture of asbestos fiber and Portland cement is first built up in laminations on an accumulator drum. The resulting wet sheet is cut by the machine shown above into shingles, which are then subjected to intensive drying and compressing processes and provided with an attractive wood-grain texture

The history of asbestos for the next 400 years is a blank, but in 1676, at a meeting of the Royal Society of London, a Chinese merchant exhibited a handkerchief of "salamander's wool" or "linum asbesti." In 1679 mention was made of an asbestos napkin belonging to Ferdinand III, exhibited in Vienna, Austria.

Italy has been called the "cradle of the asbestos industry" because the manufacture of asbestos products such as thread, fabrics and paper had its real beginning in that country as the result of studies and experiments begun in 1808. Several plants were in operation between 1860 and 1875.

Beginnings of Modern Manufacture

Although for 2,000 years mankind had known and used asbestos, it was not until about 80 years ago that its commercial possibilities began to be realized.

To a syndicate of British industrialists goes the credit for the first modern, organized effort to develop asbestos on a commercial scale. In the decade between 1860 and 1870 this syndicate experimented with deposits found in the Aosta Valley, Italy. Specimens of the fiber were exhibited in London and Paris, and considerable progress made with attempts to fabricate asbestos for machine insulation and packing, and for wall boards and papers for buildings—all highly valuable uses today.

Soon after the formation of the British syndicate a development of un-

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MIXTURE OF ASBESTOS FIBER and crushed rock passes over shaking screens which sift out the fine sand and bring the fiber to the surface where it is sucked by air into collectors.

Information and Formation in Science Classes

● By Sister M. Rogatia, O.S.B., M.S., *(Marquette University)*
COLLEGE OF ST. BENEDICT, ST. JOSEPH, MINNESOTA

This paper, which shows a capable understanding of the learning process, will interest and help science teachers who want to know more about how pupils learn and how they should be taught. It was read before a meeting of the Central Minnesota Science and Mathematics Teachers at the College of St. Benedict.

Sister Rogatia points out that a mere acquisition of facts is not enough; pupils must be able to apply principles and use generalizations. Proficiency in listening, thinking, and problem solving can be developed. Through these mental processes the pupil will acquire scientific knowledge and learn to understand and employ the scientific method.

●

In his science classes the student expects to learn a great many facts about science and to understand the application of these facts in his every day experiences. How his aim will be achieved will depend, in large measure, upon the teacher's philosophy of education and her understanding of the real needs of the student in science.

In his book, *Education at the Crossroads*, Maritain says, "The purpose of elementary and higher education is not to make of the youth a truly wise man; but to equip his mind with an ordered knowledge which will enable him to advance toward wisdom in his manhood."[1] How is this ordered knowledge to be acquired? In our science classes we aim at its acquisition in the careful formulation of our objectives. As we outline these objectives we generally include:

1. The acquisition of knowledge about science and the things of science.
2. The exploring of the fields of science to enable the student to acquire new interests, capacities, and abilities.
3. The development of the ability to think scientifically.
4. The development of a scientific attitude.
5. The acquisition of habits of accuracy, persistence, honesty, self-control, truth, punctuality, etc.
6. The development of wholesome interests in the nature and organization of the environment.

These objectives can be achieved in various ways, but I shall try to show how all of them, no matter under what phrasing they are described, can be directed toward information and formation in the students. Intellectual knowledge cannot be limited to information, the mere acquisition of facts. It must provide for the development of the mind; it must have disciplinary values; it must possess values of appreciation; and it must consider man and his problems. This is formation. This means that facility in the use of various operations involved in thought must be developed, which is in accord with the true activity of the intellect, the search for truth. This is done by imparting knowledge and by giving an understanding of this knowledge through ability to apply principles and to use generalizations.

Our major objective in science classes, therefore, is to bring students to the point where they are able to recognize applications of principles, generalizations, and fundamental facts. But they cannot apply what they do not know; hence, the first point for us to consider is the acquisition of facts through instruction in the form of reading, formal instruction, and observation. One writer refers to facts as "pegs upon which to hang one's thinking." These "pegs" are the fundamentals: the theories, laws, principles, vocabulary, simple techniques, the basic content of our particular course. Without this information, formation is impossible. The extent of the vocabulary necessary for scientific work has been brought to our attention by Muhleman in his study, "The Vocabulary of Chemistry," in which he has emphasized the need for understanding terms in chemistry before these terms, bare facts at first, become part of the student's fund of knowledge.[2] To guide students, therefore, in the use of facts is to render them a real service.

To cram students with facts is to violate intellectual integrity and to cultivate mental sterility. Every piece of information is helpful in some situation, but the mind can absorb only a limited amount. Making walking encyclopedias of students dulls the imagination and is an obstacle to creative thinking. We all agree that what is taught is less important than what is done with it. Dewey says, "But there is all the difference in the world whether the information is treated as an end in itself, or is made an integral portion of the training of thought." He stresses the same point when he says, "information, merely as information, implies no special training of intellectual capacity; wisdom is the finest fruit of that training."[3]

With these few statements on the place of facts in the learning process, we shall consider briefly three means by which facts can be made to serve the needs of the student as he progresses with his academic work, and which become a part of his fund of knowledge, that which he has "for keeps." These three factors important in the real training of the intellect are listening, thinking, and problem solving. Although teachers in all departments can assist students in acquiring facility in these mental processes, science seems to be especially adapted to it.

How many of our students really know how to listen? St. Thomas has left us a number of suggestions on how we can assist students in acquiring the habit of listening. He used to tell his pupils, "Always make sure that you actually understand what you read or listen to."[4] Nelson Bossing says, "A consideration that modern writers in education seem to have lost sight of is the responsibility of the school for the training of good listeners."[5] We all have students who are attentive in class but passive; students who do not concentrate on explanations as they are given but decide to study them later; students who observe demonstrations but are only entertained by them. Do not all of us have students who have not learned to follow either oral or written directions? How many times does it not happen that an assignment is late or incomplete because the student, through no malice on his part, did not attend to the teacher's directions at the time of making the assignment? We might do well to follow the wise old adage:

> Let him be kept from paper, pen and ink;
> So may he cease to write and learn to think.

The habit of listening can be developed, and it is our duty as teachers to assist young people in the acquisition of this very important ability. Do we insist upon the observance of details in the directions for writing papers and for laboratory procedures? Do we occasionally dictate quiz questions to see how well students can listen? Do we sometimes illustrate a law or a principle, then let students give a similar illustration; for example, working a mathematical problem in chemistry or physics? Do we go through drawings or figures only once and then call upon students to explain parts? It does not take long before students develop an awareness of their inattention. And after this, our aim is practically achieved.

Let us now consider the ability of our students to think, to do what Twiss, in his book *Science Teaching*, calls "everyday thinking." It is said that learning is learning to think, and it is the duty of teachers to assist students to become aware of the value of careful thinking. And at the same time we want them to be aware of the fact that good, solid thinking requires the accumulation of a considerable amount of knowledge and experience and practice in reflective thinking rather than automatic response. In this regard, Harry N. Holmes says:

> "My own experience in teaching more than 5000 college students has convinced me that teaching facts and theories is necessary (as tools are to a carpenter) but that the greatest contribution of the instructor is teaching the student how to think scientifically."[6]

Thinking is putting to work in a new situation old ideas already in the mind. Memorizing mechanically has its place in the educational program but not in science classes. Too much activity under the name of science teaching, at the expense of real thinking, is detrimental to growth in general knowledge as well as in science. Mechanical performance of experiments, filling in of blanks in workbooks, getting bound up in minute details of procedure, using methods for evaluation which require no thinking—all of these are opposed to the purpose of science. How do students answer our "how" and "why" questions? Do they get the thrill of success when they are able to make associations, to apply a law or a principle? We all know that they do. When they can tell you why the rings of ammonium chloride are formed in the tube about two-thirds of the way between the ammonia and the hydrogen chloride plugs in the glass tube, they have done real thinking. When they can illustrate theory by giving practical applications or using mathematical problems, they are thinking. When they can write paragraphs answering questions such as: "Why is the formula for oxygen O_2 and not O?" they must understand the meaning of laws and principles. When they can apply classroom discussion to the laboratory experiments, they must think. But if students are to acquire the art of thinking, real effort is demanded on the part of the teacher as well as on the part of the student.

Now let us consider the question of problems. The mastery of problems requires the student to use a scientific method which will foster in him the scientific attitude. This alone will bring him to a solution and give him facility in problem solving. A. G. Hoff, states:

> "As the scientific attitude appears to be a characteristic which is different from general intelligence, and since it is a desirable attribute for an individual to possess to an appreciable degree, it merits rating as a major objective in science teaching."

He adds, too, that,

> "Any evidence that those pupils who have studied science in the secondary school and do not possess the scientific attitudes to a greater degree than those who have not received this training may be due to inefficient teaching . . . . . It may be the result of inadequate understanding and application of scientific information learned."[7]

In discussing the disciplinary values of science, Brother Leo says:

> "This requirement is satisfied by the most basic objective of science teaching, whether at the elementary or college level; and this is training in the scientific method of learning, the observation-hypothesis-verification-generalization-prediction procedure."

"Writers," he goes on to say, "unanimously stress the fact that this method of science is far more significant than the facts of science."[8]

Until quite recently it was assumed that if the content of science courses was thoroughly learned, scientific attitudes would develop concomitantly. Rather it has been found that they must be sought directly through procedures in the classroom if they are to be realized; they must be taught systematically in the same manner as we try to develop a mastery of the principles of science.

From this it becomes evident that just as in learning to listen and in learning to think it is the teacher who must guide and be the example, so likewise, it is the teacher who must show the way with the scientific method. But the ability on the part of the teacher to assist students to acquire this scientific method demands a clear view of the procedure involved. In his article, "The Scientific Method as a Teaching Procedure," Gordon Mork presents an outline of how the steps in the scientific method can be adapted by the teacher to her classroom procedure.[9] Let us see how

the teacher can assist students in their use of the method.

We, as teachers, must help the student select a problem and to state it in clear, concise English; we must help him collect information through the use of basic skills in using library facilities, interviews, experiments, visual aids. Frank, in discussing the Scientific Method says, "Scientists, like newspaper reporters, have to be trained in the gathering of facts."[10] It is our responsibility to teach students how to read science material. We must plan exercises which will develop the power of observation; help them draw inferences on the basis of evidence; show them how to arrange and tabulate data. Henshaw Ward, in "The Goals of High School Science," points out that the teacher who gives his class even an inkling of what true evidence is has made their intellectual lives safer and better.[11]

The next step in the process of acquiring skill in using the scientific method is the interpreting of the data. Here the student must be able to analyze in order to recognize fundamentals, to discern inconsistencies, to establish causes, to predict effects, and finally to evaluate data. Then he is ready to propose and test hypotheses for the solution of the problem. This requires the use of his ability to judge pertinency of data, to propose tests for the hypotheses. This step in the scientific process of reasoning is often omitted—going rather directly from data to conclusion. But problems should be selected in such a way that hypotheses can be set up. Undoubtedly, learning how to use this step in problem-solving would bring about at least some transfer to other problems in life, since it requires a careful weighing of all factors and not a rushing into decisions.

It may happen that the tested hypothesis is the conclusion, or the conclusion may be drawn from the data directly. Here the ability to make generalizations concisely is called into use. Everything that was done to prove the problem should be used to provide evidence. The student must see the generalization as a broader view and meaning of problems with which he has already had some contact.

The last step in the scientific method of thinking is the application of the generalizations to new situations. If the student concludes that the addition of acid to a carbonate yields carbon dioxide, does he see at once why the addition of acid to baking soda yields carbon dioxide? If he concludes that carbonates and sulfites are decomposed by dilute acid, does he, after having tested carbonates, recognize the reaction between hydrochloric acid and sodium sulfite? If he concludes that all hydrates give up their water of hydration when their vapor pressure exceeds atmospheric pressure, does he know why all hydrates would effloresce in a vacuum? If students draw conclusions from observation and experiment rather than from knowledge of principles learned before observations are made, conclusions become a part of their real knowledge because they will be the result of thinking and making associations. As in the other steps in the process, so in this one, the student shows his ability or weakness in the use of scientific thinking. Studies have shown that usually inability to use a generalization is due to lack of knowledge of the principle involved (due to not mastering facts involved), inability to see applications, (due to lack of ability to make associations), or inability to tell why things happened as they did. These studies give points teachers must recognize if the pitfalls in applying principles are to be avoided.

If science teaching is to serve its greatest function, it must train young people to think. Emphasis must be transferred, as Hunter says, "from fact learning to fact usage in problem solving."[12] If this is accomplished in its broad concept of scientific thinking, students will exhibit it through their scientific attitude, or as it is sometimes called, "trained common sense," which manifests itself by such elements as: conviction of universal laws of cause and effect, sensitive curiosity concerning reasons for happenings, habit of delayed response, habit of weighing evidence for pertinence, soundness, adequacy, and respect for the viewpoint and opinions of others.

All methods, devices, and techniques used by teachers can help students to acquire proficiency in listening, thinking and problem solving if the teacher, conscious of their importance in the life of students as students, as well as in later life, works directly for their attainment in her science classes. The scientific method is most successfully taught by the teacher who uses it herself in teaching the content of her course. All devices and techniques such as field trips, excursions, movies, demonstrations, laboratory work, mathematical problems, projects, and experiments—all these develop attitudes, ideals, habits, interests, and powers in the student if they are used with these formation elements in mind.

And from this we can conclude that listening, thinking, and problem-solving, if mastered by the student will enable him "to advance toward wisdom in his manhood"; they will provide him with both information and formation. ●

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XVIII Century Soda Water

● By John J. Riley
SECRETARY, AMERICAN BOTTLERS OF CARBONATED BEVERAGES, WASHINGTON, D. C.

This is a brief account of how artificially carbonated beverages were first made, and how they have developed into the typically American carbonated beverage, or soft drink.

Mr. Riley has written an interesting booklet "Scientific and Medical Origin of Carbonated Waters" which is available for free distribution. Requests should be addressed to Mr. Riley.

●

What is it—a new style of coffee percolator?

No — it is one of the earliest types of apparatus for making carbonated water dating back to pre-Revolutionary days, and it is therefore the forerunner of the soda fountain and the carbonated beverage bottling plant.

The device illustrated was made of heavy glass, in three sections. The hollow interior of the bottom vessel provided the chamber into which was put chalk and acid for generating carbon dioxide. The middle vessel was fitted with a valve in the bottom, fitted closely over the bottom vessel, and filled with water. As the gas pressure in the base section forced the gas through the valve and into the middle vessel containing the water, a portion of its water content was displaced and forced into the top vessel through the tubular projection depending from it. The water and gas in the middle vessel were then mixed by agitation. Then, the carbonated water was ready for drinking, so the top and bottom vessel were removed and the water poured.

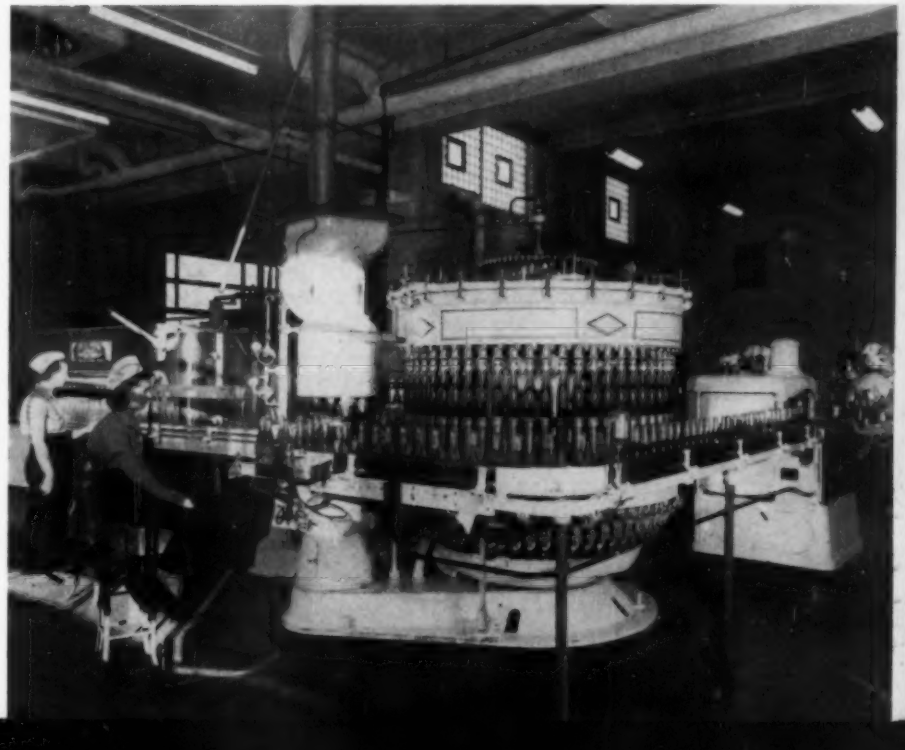
The device illustrated was made by Dr. John Mervin Nooth, of England, as an improvement over previous means used by the early experimenters with artificial carbonating of waters—Henry Cavendish, famous English scientist; Thomas Lane, London apothecary, and Joseph Priestley, a clergyman-scientist. All of the latter had explained and demonstrated their experiments before the Royal Society of London. Likewise, Nooth's improved device was the subject of an appearance by him before that organization of learned scientists in December, 1774. His discussion and the design of the apparatus were published in the Philosophical Transactions of the Society, issued in 1775.

Obviously, the Nooth apparatus was recognized as a substantial improvement in the methods of artificially carbonating water, for it was given recognition as "one of the most ingenious" by Chaptal, famous French chemist in his *Elements of Chemistry*, the English edition of which first appeared in 1791. Subjected to minor improvements by Magellan and Henry, its use in the preparation of carbonated waters for medical purposes was recommended in 1794 by Dr. John Moncreiff, physician-apothecary, an Honor Member of the Royal Society of Edinburgh. In that year Moncreiff published his treatise *Medicinal Qualities and Effects of Aerated Alkaline Waters*, in Edinburgh.

The fame of Nooth's carbonator spread to America and became well known in Philadelphia, then the center of medical and scientific education. There, shortly after he was elected professor of chemistry at Yale College in 1802, Dr. Benjamin Silliman became acquainted with it during the course of his chemistry studies under Dr. Woodhouse, at the medical school of the University of Pennsylvania. And among the few items of chemical apparatus with which Silliman began his instruction at Yale, in 1804, was one of the carbonating devices of Nooth.

To Silliman, in New Haven, is credited the commercial production, as early as 1806, of what by then was known as "soda water." At that time, according to

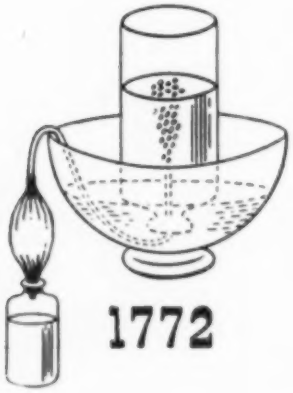
A MODERN bottling machine.



the 1809 American edition of *Conversations on Chemistry*, he endeavored to provide the effervescent waters made according to correct chemical principles, and opened a public establishment for their dispensing.

Similarly, and at about the same time, Joseph Hawkins of the Philadelphia firm of Shaw and Hawkins, undertook the preparation and commercial dispensing of carbonated waters in bottles and also by means of a fountain apparatus he invented. Hawkins was the first American patentee in the art of making artificially carbonated waters.

Then began an era of commercial development of this new type of beverage. Philadelphia druggists of the early nineteenth century, such as Durand, Glentworth, Smith and Hogdson, and others, were among the purveyors, while in New York City George Usher, Noyes Darling and Company, and the drug firm of Hull and Bowne, were similarly engaged. Shortly after the first quarter of the century the use of syrups and other flavoring materials gave added impetus to this new adjunct to the druggist's business.



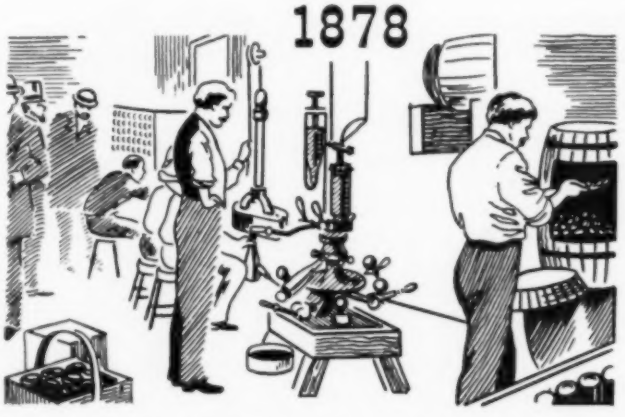
JOSEPH PRIESTLEY, English teacher, preacher and scientist, is generally conceded to have been one of the first to develop an artificial means of carbonating water. His pamphlet, "Directions for Impregnating Water With Fixed Air," published in 1772, urged the British Admiralty to employ his equipment on warships for the purpose of preventing or curing scurvy.

For the greater part of the nineteenth century following the early studies and experiments on artificial carbonation of waters, by European and American scientists, the generating of the carbon dioxide used was one of the processes required by every beverage manufacturer or soda fountain. In general the process was based upon the separation of the gas from an alkaline mineral salt by treatment with acid, purification of the gas, and impregnation of the water with it by agitation under pressure.

However, carbon dioxide was one of the first gases to be liquefied. While this was first accomplished in 1823 as a result of the efforts of Davy and Faraday, liquid carbon dioxide was not adapted to commercial use until more than fifty years later. Thilorier, teacher in the Ecole de Pharmacie in Paris, France, in 1835 undertook to repeat the liquefaction experiments on a larger scale, and is credited with being the first to solidify carbon dioxide in an experimental way. Many other studies followed in the years which preceded its introduction in liquid form, about 1884, for use by American carbonated beverage manufacturers. With a supply of liquid carbon dioxide available for expansion into gas in the carbonating process the manufacture of beverages was greatly simplified, and products of better quality made possible.

AMONG THE EARLIER bottling machines, the "Knee Bottler" brought the bottle mouth against the leather filling nipple by pressing the knee-board upward.

Liquefaction of carbon dioxide also made it practicable to obtain and use the gas from several sources, and to ship it to distant points. In recent years the introduction of the solid gas, or "dry ice," also has facilitated its use. At the present time, much of the carbon dioxide used in the United States comes as a by-product of the burning of limestone, coke, fuel oil, or natural gas. The same source as that used by Priestley — fermentation — also produces the gas for manufacturing purposes, but in relatively small quantities. Natural wells are a minor source of supply. ●



BY THE LATE '80's and early '90's, early bottling was done largely with foot or hand-operated filling machines, but bottle washing had entered the water pressure and steam sterilizing stage.

★ ★ ★ ★ ★

"But we find among the college-bred, too, many technically trained barbarians,—minds in a groove. We do not prepare our young people to resist effectively the growing brutalization of men."

—Otto F. Kraushaar, *President, Goucher College*

NEW BOOKS

Popular Gemology

• *By* RICHARD M. PEARL. New York: John Wiley & Sons, Inc. 1948. Pp. XII + 316. $4.00.

Anyone who loves gems—and who doesn't?—will find this book filled with fascinating information. The work of a noted mineralogist and geologist it is authoritative and up to date, but it is written so simply that the layman can understand it. The jeweler and the lapidary will find it useful.

Gems are classified according to the style of their cutting—facet or cabochon. Those of the silica group receive special consideration. There are chapters on gem recognition, on man-made gems, on pearls and other gems with a genealogy, and on the appearance of gems under ultraviolet light. The scientific and industrial uses of gems are discussed. There are many clear photographs and drawings.

H. C. M.

Man on the Landscape

• *By* VERNON GILL CARTER. Washington, D. C.: National Wildlife Federation. 1949. Pp. XV + 129. $1.50.

The National Wildlife Federation and author Carter are to be congratulated on producing such a thought provoking book on one of our important national problems. It is factual, pungent, and alarming. If everyone should be concerned about the conservation of our national resources, and they should be, everyone should read this book. It is a must for all engaged in conservation education.

The book shows the importance of plants in promoting the welfare of man. It discusses the social and personal problems that result from deficiencies in the quality or quantity of vegetation, points out the complexities of the relationships found in the landscape, demonstrates how man may relieve and avoid trouble by good landscape management, and suggests ways and means of teaching conservation.

Page 114 suggests pertinent activities connected with Chapter II. It lists projects for all teachers, then one for the master teacher, one for the "teacher in a thousand," and one labeled "We do not expect anyone to do this"!

H. C. M.

Introduction to Human Anatomy

• *By* CARL C. FRANCIS, A.B., M.D. St. Louis: C. V. Mosby Co. 1949. Pp. 442. $5.50.

The chief feature of this book is the presentation of the essentials of body structure in a clear, descriptive style aided by suitable illustrations and diagrams.

Arranged into units and subdivided into chapters, the material progresses from simple structures to the identification and location of the more detailed and intricate parts of the human body. The external and internal parts are named first, followed by the various systems (nervous, circulatory, etc.) which integrate and maintain body functions. The last unit describes the structure of the reproductive system.

Accompanied with proper laboratory instruction, this book is recommended as a text for students in nursing, pharmacy or psychology who may require only the essentials of anatomy in preparation for physiology and related subjects. It may also serve as a review for anatomy, or to accompany courses which treat both physiology and anatomy as a unit.

To aid the student in visualizing the various parts described, the book contains 313 illustrations and 35 color plates. A glossary of terms is included.

Alfred Halpern

Principles and Practice In Organic Chemistry

• *By* HOWARD J. LUCAS and DAVID PRISSMAN. New York: John Wiley and Sons, Inc. 1949. Pp. 557. $6.00.

The authors subject organic laboratory work to a thermodynamic treatment in an attempt to explain "cook-book" procedures on a more scientific basis. In this attempt they succeed within the qualitative limits permitted by the translation of bond energy values to reactions carried out in solutions. It is therefore commendable that the student of organic chemistry is shown ways of predicting the outcome of reactions from the viewpoint of energy changes.

The reviewer is puzzled by the background requirement which must be met before the student can make full use of this book. A sophomore, or even a junior, unless exposed previously to a discussion of free energies, entropies, heat contents, could hardly be expected to master the significance of these terms to the point of using them throughout the book unless additional lecture material is provided. Presumably it is anticipated that the student will be studying physical chemistry concurrently, as is the practice at California Institute of Technology and some other schools. Even so, he would certainly have difficulty in comprehending the very first chapters until fairly late in the course. The laboratory experiments range from the conventional simple preparations to more ambitious syntheses. The procedures are excellent, with many hints, precautions, and explanations provided in the form of footnotes.

This book, will be of great use for any advanced work in organic chemistry. The elementary student may not understand completely all the material which the book offers when he is first exposed to it, but he will learn to appreciate it more the longer he stays in the field of organic chemistry.

H. H. Szmant
Department of Chemistry
Duquesne University

Free and Inexpensive Learning Materials

• Division of Surveys and Field Service, George Peabody College for Teachers. Nashville. 1949. Pp. 175. $0.25.

To teachers in primary or secondary schools this paper bound book is worth many times its cost. It contains much that will be useful to science teachers. It lists under 250 headings helpful learning aids that may be obtained from specified sources either free or at a cost of fifty cents or less. A number of instructors and undergraduate and graduate students cooperated in collecting the material and evaluating it as to content, timeliness, method of presentation and educational purpose. The project was planned and directed jointly by the Division of Surveys and Field Services and the Librarians of the Peabody College for Teachers. They have done a good job. *H. C. M.*

Plane Geometry

• *By* WM. G. SHUTE, WM. W. SHIRK, and GEORGE F. PORTER. New York: American Book Co. 1949. Pp. viii + 406. $2.48.

Experienced teachers of plane geometry will "recognize" this as a superior textbook. Sometimes, texts are prepared by persons who are not actively engaged in teaching the subject. Here is one written in "teacher's language" by three expert teachers in the field. It is a text that students will like and be able to understand. Its make-up and general appearance are excellent.

Enough problems and working materials are provided so that teachers will not have to spend time hunting for or preparing extra problems. Students will like the abbreviated form of proofs and the symbols that are placed on the geometric figures to help them sense quickly what is given and what is to be proved. The many examples which are solved will provide extra help for pupils who need it. Those who complete all the work of this fine text will have a splendid preparation for later studies in the field of geometry.

Robert E. Smith
Department of Mathematics
Duquesne University

Amphibians and Reptiles of the Pacific States

• *By* GAYLE PICKWELL. Stanford University, California: Stanford University Press. 1947. Pp. 236. $4.00.

An excellent book which every herpetologist should add to his library. The amphibians found in the region are studied first; a consideration of the reptiles follows. Chapters IV and V deal with life histories and habits. While much is known about these animals from a taxonomic standpoint, there are great gaps in our knowledge of their life histories. For example, the desert-dwelling forms present many interesting specializations in their mode of living to enable them to survive under conditions of rapidly changing intensities of heat and cold, with often a very limited supply of water. The author is to be complimented on his chapters on life habits.

By far the finest feature of this book is the excellent half-tone illustrations of the amphibians and reptiles of the selected area. The appendix contains excellent keys to aid in identification of specimens. The book is nicely bound and printed on a dull-surface paper which makes reading by artificial light easy.

Robert M. Wotton
Department of Biological Sciences
Duquesne University

Skyshooting

• *By* R. NEWTON MAXWELL and MARGARET L. MAXWELL. New York: Ronald Press Co. 1949. Pp. xi + 174. $3.75.

"Skyshooting" will appeal to both amateur photographers and amateur astronomers. It tells what there is to photograph in the sky and how to do it. Explicit directions are given for the photographing of meteors, stars, planets, nebulae, etc. There is information about astronomy and telescopes and telescope mountings as well as on photographic equipment, plates and films, developing, printing, and enlarging. One who follows carefully the directions given is assured of success. The authors state (p. 117): "Only on the photographic plate and film can the beauty and wonders of the universe be brought to human ken. We have outlined what there is in the sky—the rest is up to you. Good luck!" *H. C. M.*

Chemistry for the New Age

• *By* ROBERT H. CARLETON and FLOYD F. CARPENTER. Philadelphia: J. B. Lippincott Company. 1949. Pp. xiv + 688. $3.20.

This book impresses the reader first by its attractive binding, copious illustrations and good make-up; then by its wise planning, its somewhat different arrangement, and its careful writing. Both bookmaker and authors are to be congratulated on their joint achievement.

The long experience of the authors in the high school field is reflected in the selection of subject matter that is suited to the needs and abilities of the pupils who will use the book, material that can justifiably be included in a text designed for both non-college and college-preparatory groups. There are nine units composed of twenty-two chapters which are divided into fifty-eight sections. An appendix of useful tables and a glossary of chemical terms are included. Excellent teaching aids are to be found in each section.

Teachers seeking a modern not-too-easy, not-too-difficult text, one that will challenge their pupils, should examine this book with special care.

H. C. M.

Encyclopedia of World Timbers

• *By* F. H. TITMUSS. New York: Philosophical Library. 1949. Pp. vi + 156. $4.75.

The first part of this book explains how a tree grows, studies the structure of wood, distinguishes hardwoods and softwoods, and shows how woods may be identified both macroscopically and microscopically. Most of the book is devoted to detailed descriptions of some 200 timbers, giving sources, effect of seasoning, workability, and much other valuable information. Rather complete macroscopic identification is supplied for many woods. Frequently, the reader is referred to sources of additional information.

H. C. M.

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The most teachable organic text available today. Presents organic chemistry in a concise manner without sacrificing vital concepts, and effects a liaison between previous work done in chemistry and that which is to follow. Nomenclature, the graphic formula, functional groups in reactions, relationship of simple compounds to each other are stressed. Chapters on biochemistry provide material for those who wish a short survey of organic chemistry along with the nutritional aspects of biochemistry. Many helpful suggestions included.

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Religious Responsibilities

(Continued from Page 120)

"In no country in the world, at this time, do we see such a perfect illustration of these multitudinous controversies in the name of humanity as we do in the United States. If this is what most of my countrymen mean by Democracy, then I reply that with such opportunity for the expression of diversity there must be also a greater spirit of responsibility by the leaders of these dissident national organizations to the people as a whole." (R.M.F.)

It was not until I had given this criticism of the behavior of my American (U.S.A.) colleagues that I addressed the Chairman of the Russian Delegates openly at the Council Meeting as I did.

On December 1, 1948, Dr. Walter R. Hunt, Vice-Chairman, Committee on Physics, Metaphysics and Religion, CSVES, IUGG, wrote to Dr. K. T. Compton, President, M.I.T., as follows:

"In reading the draft of the Report of the International Committee on the Social Value of the Earth's Sciences, of which Dr. Field is Chairman, I was deeply impressed by the opinion expressed by you in a letter to Dr. Field relative to 'the responsibility or the right' of scientists to dictate to society with reference to the use made of their work.

"I was reminded of the reply by Charles F. Kettering at a recent Harvard Commencement to the charge made earlier in the exercises that Science alone was responsible for the destruction made possible by its inventions.

"His retort was to the effect that the responsibility lay at the door not of Science, it rested upon Society as a whole. Science does indeed make its inventions and discoveries, but Society has not the wit to know what to do with them.

"As a minister of Religion I feel keenly that the Church, the School and the Home have a duty and a field in which their labors may be more productive than in the area of theological controversy alone.

"What we need is not more Scapegoats, but more willing appreciative workers in their respective fields for the attainment of the possible goals, which as yet we see but dimly."

On December 8, 1948, R. M. Field replied to K. T. Compton and Dr. Hunt as follows:

"I and my colleagues of the CSVES, IUGG, and particularly the members of its sub-committee on Physics, Metaphysics and Religion thank you for your most helpful and pertinent criticism of the *MEMORANDUM*. I herewith add my final comments and I am sending mimeographed copies of the completed *MEMORANDUM* to all members of the CCOS, CSVES, the President and the General Secretary, IUGG, and to Dr. John A. Fleming, President of the International Council of Scientific Unions for their final criticism.

"I note that Joseph Needham, Walter B. Cannon, Richard M. Field and Karl T. Compton all agree that 'science has risen to the consular level.' I also note that both Karl T. Compton and Dr. Hunt agree that scientists have neither the responsibility nor the right to attempt to *dictate* to the society of which they are a part with reference to the use that is made of their work. Also I deeply appreciate Dr. Compton's statement: 'I am sure that you (R.M.F.) did not have anything like this in mind, but I do sometimes feel that some scientists fail to realize that there are a good many more angles to the decision in some social problems than simply their own contribution, important as it may be.' Of course scientists should never *dictate*, but scientists as a most significant part of society have an ever increasing consiliary responsibility in most of the complicated problems of human welfare. Above all I agree with Dr. Hunt that: 'What we need is not more *scapegoats*, but more willing, appreciative workers in their respective fields for the attainment of the possible goals, which we yet can see but dimly.' "

The most important of our national and international problems do not stem from national or international isms in ideology or religion, but from the unequal distribution of natural resources, especially power resources, whose discovery, exploration and exploitation are primarily the technical responsibility of scientists and engineers.

The further discussion of our international investigation regarding the use and misuse of natural resources will soon be published by a sub-committee of the CSVES, IUGG together with the conclusions of its other sub-committees, including the sub-committee on Press, Radio, Publicity, Propaganda, and the sub-committee on Education. However, because the ultimate happiness of the living human organism depends as much upon its spirit as it does upon its metabolism, the work of the sub-committee on Physics, Metaphysics and Religion—Sir Richard Tute, Chairman; Dr. Walter R. Hunt, Vice-Chairman,—has become the most difficult, and, at times, the most annoying of all the many divergent and intricate implications in our scientific investigation of the Social Value of the Earth Sciences.

As Chairman of both the Commission on Continental and Oceanic Structure and the Committee on the Social Value of the Earth Sciences I found that for a time, at least, it was possible—because of "Operation Vanity" and in spite of so-called "national security" even during World War II—to collect by means of the CCOS all the technological data essential to a scientific understanding of the world's present and predictable material resources. When it came, however, to the much more emotional and arduous task of a scientific analysis by the CSVES, IUGG of why man constantly attempts to conquer his environment by genocide rather than by intelligence, it was found that very few U. S. A. scientists were willing to work on this problem until it became more fashionable, or at least they were sure of more publicity.

Fortunately, for the Chairman, the relatively small original personnel of the CSVES as appointed at the Extra-Ordinary Meeting of the General Assembly, IUGG, held at Cambridge, England in 1945, did valiant work, especially those representing Norway, Switzerland, Italy, Great Britain, France, Netherlands, Sweden, Denmark, Canada and Mexico. The coöperative labors of these official members included their power and ability to coopt the advice of interested experts from the rest of western Europe, including Finland and Poland, and also all countries in the Americas south of Mexico.

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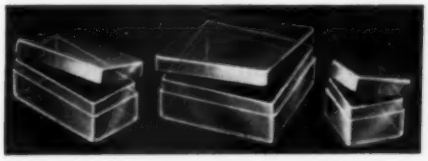

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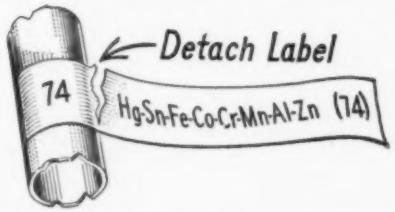

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What so many evolutionists, especially biologists and paleontologists, fail to realize is that, due to science and engineering, for the first time in the history of the earth a genus Homo, without modification of its body form and the consequent devolution of its brain, is able to invade all the environments of all other living organisms. According to this principle of adaptive or radial evolution man has only man to conquer. As a scientist I prefer to believe that he will eventually conquer by his accumulated and coöperative intelligence rather than by genocide. As a philosopher I wish to believe that he will continue, no matter how confused or discouraged by his material accomplishments, to realize the ever increasing need of developing his spiritual powers.

Finally, we scientists must always remember that no characteristic of race, or of a nation, or of an individual or group of individuals, is so thoroughly a human characteristic as his religion and his way of expressing it —for a human being's religion is a fundamental phenomenon of his natural environment. ●

★ ★ ★ ★ ★

"Continuous research by our best scientists is the key to American scientific leadership and true national security."

PRESIDENT HARRY S. TRUMAN

Pittsburgh Science Meeting

Plans are nearly complete for the one-day meeting of the Pittsburgh Diocesan Science and Mathematics Teachers Association which will be held at Duquesne University on Saturday, February 18, 1950. The meeting is sponsored by the Biology Section under the direction of Sister M. Gabriella. Addresses will be made by Dr. Max Lauffer and Dr. Peter Gray of the University of Pittsburgh and by Dr. Alfred Halpern and others of Duquesne University. Demonstrations by teachers will be given at the sectional meetings, which will be devoted to botany, zoology, and physics and chemistry.

★ ★ ★ ★ ★

Mathematics Teachers Meet at Wichita

The Tenth Christmas meeting of the National Council of Teachers of Mathematics will be held at Wichita, Kansas, December 28-30, 1949.

There will be sectional meetings for teachers of elementary schools, junior high schools, secondary schools, and colleges. Mathematical models, teaching aids and textbooks will be on display.

Copies of the program may be obtained from Mr. Kenneth Nickel, Wichita High School East, Wichita, Kansas.

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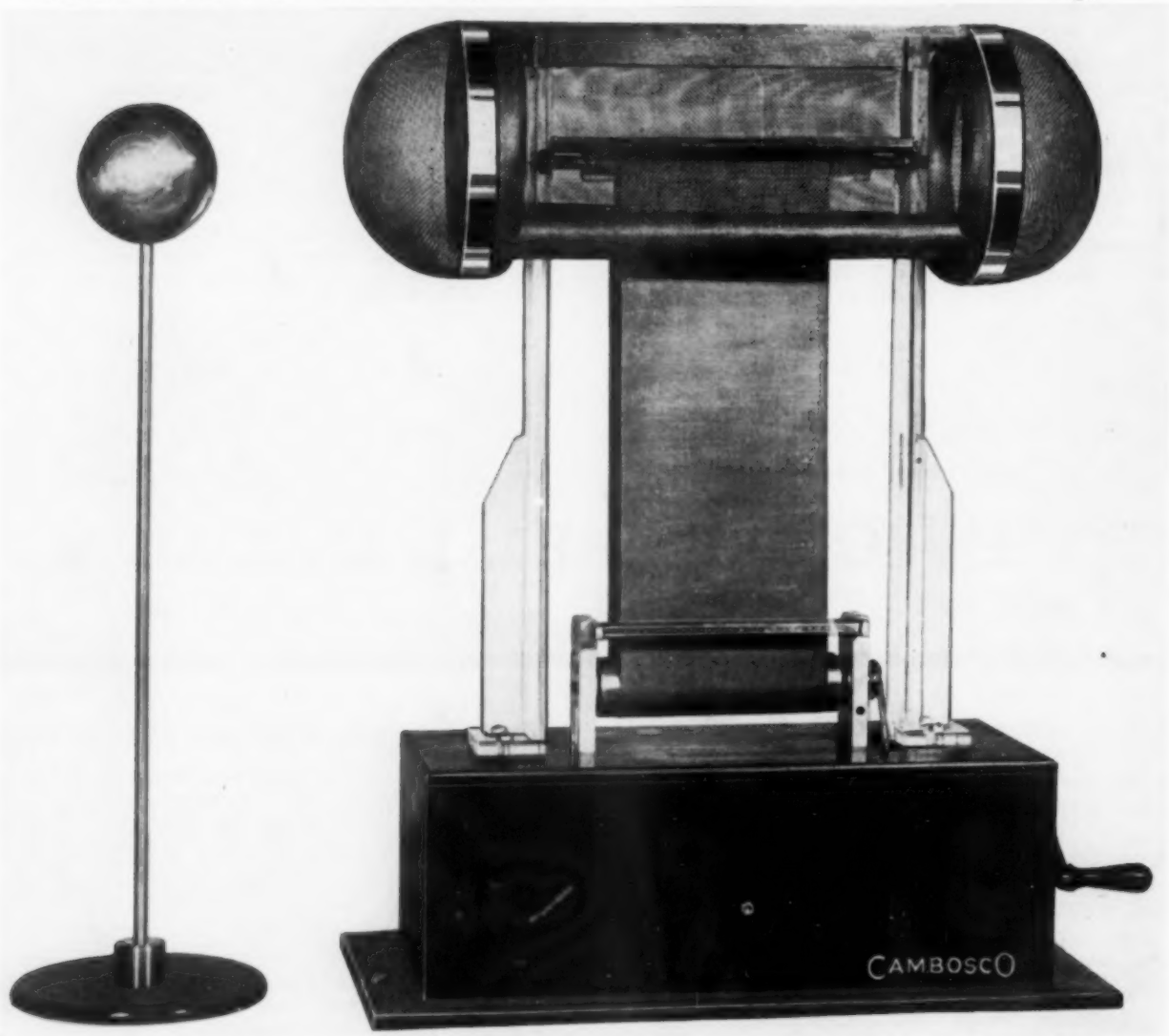

● At the *first turn* of the crank, this new Electrostatic Generator delivers a crashing spark . . . whether the day is dry or humid! On that basis alone, it will be welcomed by every physics lecturer who has ever apologized for the temperamental performance of an old fashioned "static machine."

● Like its larger counterparts, to which Nuclear Physics owes so much, the Firsturn Generator consists, essentially, of an endless, charge-conveying belt, which is here reduced to its simplest, most comprehensible terms.

● The belt travels from an adjustable roller of solid brass to a fixed roller, of high dielectric material, supported on massive pillars of lucite. Full visibility is afforded by the upper terminal—a large, closed cylinder of woven bronze wire from which the spark jumps to the separately mounted discharge ball of brass.

● Under normal operating conditions, a spark is produced with each revolution of the drive shaft.

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Native American Gemstones

(Continued from Page 114)

richest sapphire mine. Although mining has been dormant since the demand for corundum for instrument bearings ceased with the end of the war, the former annual output reached as high as $450,000, about fifteen per cent of the stones being used for gems, the rest going into industry.

Diamond production in the United States is more interesting than important. Isolated finds of occasional crystals in many of the states are intriguing because they suggest primary deposits still undiscovered. The occurrence of diamond in Pike County, Arkansas, however, is one of the few outside Africa in which this mineral is found in its original rock, a weathered and brecciated peridotite called kimberlite. The earliest specimens were picked up in 1906 on his farm by John Huddleston. Ten thousand or more have been recovered since, the largest weighing forty carats. No criticism of their fine quality can be raised; nevertheless the history of the deposit has been one of many vicissitudes. Another attempt to mine it commercially or to develop it as a domestic source of strategic industrial diamonds is being made at the present time.

Nevada and Colorado have furnished most of the turquoise mined in the United States in recent years. Whereas New Mexico was for centuries by far the leading producer, its extensive deposits are almost exhausted. The only crystallized turquoise reported to date was found in Campbell County, Virginia, in 1911. Turquoise otherwise occurs in vein and nodular forms, filling preexistent openings in shallow-seated rocks. It is a hydrous phosphate of aluminum and copper; iron partly replaces either or both of the other metals. The cause of color in turquoise has not yet been determined with any assurance.

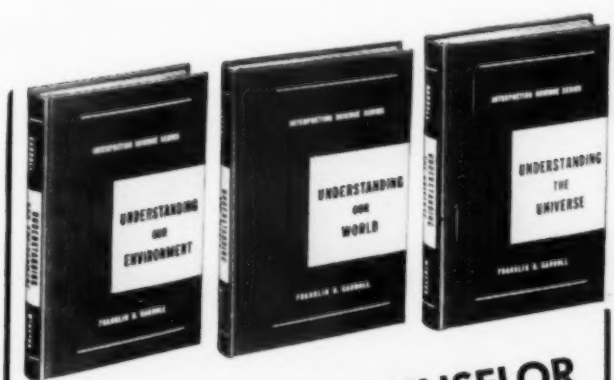
Tourmaline is a gem of such complex composition that John Ruskin wrote, "The chemistry of it is more like a medieval doctor's prescription than the making of a respectable mineral." Its numerous exquisite colors are all found in American specimens. Maine and California lead the states in total production, having yielded material of many hues, singly and in remarkable combination. Owing to its property of piezoelectricity tourmaline is also used to detect small variations in pressure, as in submarines.

Too frequently subject to cracking upon exposure to the atmosphere, Nevada opal does not bring the price of the Australian gem, but its rich glow of colors smoldering against a dark blue background is equally beautiful. Such specimens are called black opal to distinguish them from the light or Hungarian opal taken from ancient mines in Czechoslovakia. Some of the best Nevada opal, found in sun-parched Virgin Valley, occurs as a replacement of fossil wood, shells, and bones.

A trend toward increased emphasis upon the teaching of the earth sciences in secondary schools in the United States has been evident for several years. This emphasis is in part both the cause and the effect of the rapidly growing interest in mineral collecting, mineral study, and lapidary work by amateurs and laymen in this country.

The minerals of chief interest to this group are quartz and chalcedony, which are related in composition and structure. Their many varieties go under a bewildering multiplicity of names. Their advantage over the thousand or more other known mineral species lies in their abundance, intriguing colors and patterns, and moderate hardness—soft enough to be fashioned readily, hard enough to be challenging. Practically every Western county has almost unlimited specimens of quartz and chalcedony, particularly agate, jasper, and petrified wood, waiting for the collector.

The future of the gem industry in the United States seems most favorable. Although the number of professional mineral prospectors, some of whom uncovered gem pockets while looking for gold and silver, has decreased, even more specimen collectors have taken their places. Scarcely a year passes without a new source of reasonable size being found. When the high value of gemstones is considered in relation to their bulk, it is apparent that only a very small area is required to yield gems enough to surpass previous finds in importance. In general, the more rugged the topography, the more highly mineralized is the crust of the earth—and the less thoroughly explored is the land. ●



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Photosynthesis

(Continued from Page 117)

the fructose part than in the glucose. This meant that the C^{14} was incorporated in intermediates with the fructose structure sooner than in those with glucose structures. The result of such experiments is the probable sequence of events in sugar synthesis given briefly in the foregoing scheme.

The path of carbon to sugar now seems fairly straightforward and similar to the reverse sequence in sugar oxidation by animals, but the exact sequence of reactions involved in the regeneration of the initial two-carbon starting material is more obscure. It is apparent that another CO_2 is added during the process to make a four carbon acid (oxalacetic) labeled in the carboxyl groups which is split into two new acceptor molecules. This splitting is probably unique in plants. The compounds involved are mainly carboxylic acids. By determining the position of C^{14} in the molecules after various times it will be possible to determine the sequence of reactions.

At several points in the sequence of reactions reducing energy must be supplied. This reducing power is that produced by the light. Without a steady source of light energy the system would soon reverse and run backwards, since plants respire just as animals do. It is necessary to understand the relationship between photosynthesis and respiration since both occur simultaneously in the light. It appears that plant respiration in the dark involves the same reactions (Krebs cycle) used by animal tissues. It is readily seen that the respiration process is not the same as photosynthesis even though the two have some intermediates in common. This overlapping of respiration and photosynthesis makes the plant a more efficient organism but severely complicates the study of the carbon dioxide reduction. We are merely on the threshold of understanding these relationships.

Once the sequence of compounds involved in photosynthesis is known it will be possible to extend our knowledge to the process by which plants produce fats and proteins as well. All of these products stem from the original cycle of photosynthesis. At various points in the cycle intermediates are drained off for the synthesis of all material in plants.

It may eventually be possible for man to effectively block certain of these synthetic paths. Some progress has already been made by workers studying plant nutrition in an empirical manner. H. A. Spoehr of The Carnegie Institution of Washington at Stanford has grown the alga, *Chlorella*, which is normally largely protein under conditions where it is almost all fat. Such diversion of the plant's photosynthetic processes toward production of much needed fuels and food for mankind is a most worthwhile goal. Though it is yet only a dream, the atomic age will make it possible for man to understand and harness the fundamental chemical reaction of nature. ●

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★ ★ ★ ★ ★

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—Harold W. Dodds, *Pres., Princeton University*
The Liberal Arts—A Challenge to Communism
Assn. of American Colleges Bulletin, October '49

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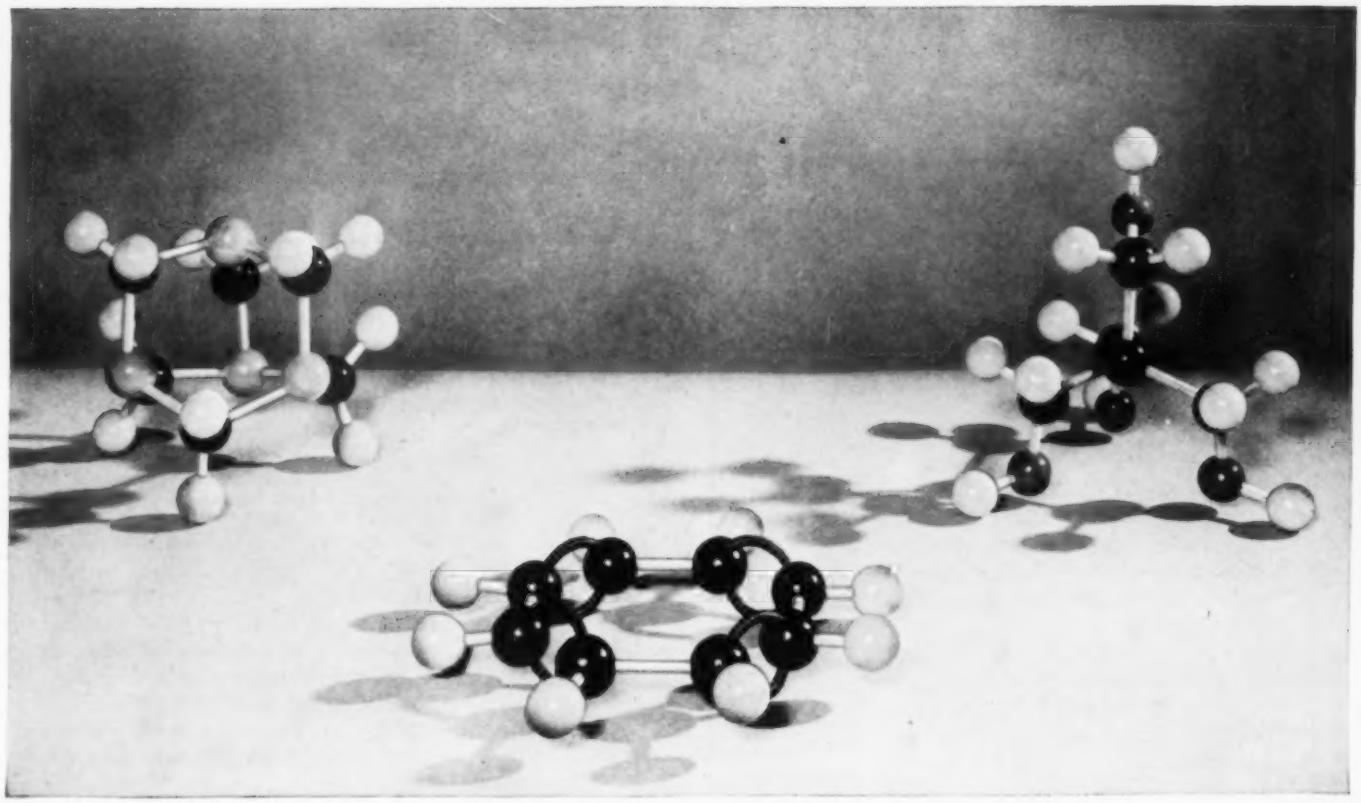

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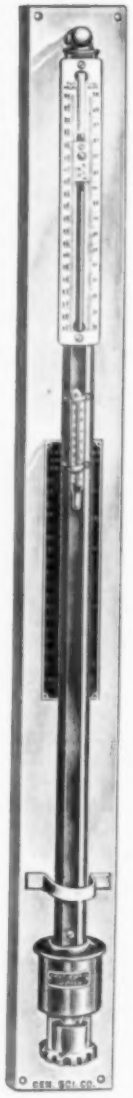

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The Story of Asbestos

(Continued from Page 131)

usual importance occurred on this side of the Atlantic —the discovery in Canada in 1877 of what is probably one of the world's largest deposits of commercially valuable asbestos.

Up to 1900, commercial interest in asbestos had centered largely on the idea of converting the fiber into fabrics, pads for protection against heat, pliable boards and papers for use as pipe and furnace coverings, and for protecting parts of machinery where heat resistance is required.

During the closing year of the last century, however, Ludwig Hatschek, an Austrian, developed a method of combining asbestos fiber with Portland cement to provide an effect comparable in some measure, to that of steel reinforced concrete. One result was the gradual development of many forms of asbestos-cement building products, such as the asbestos-cement roof siding shingles which today protect and adorn so many American homes, corrugated sheets of asbestos-cement roofing and siding for industrial buildings, and various types of asbestos-cement boards adapted to manifold building purposes.

Mining Asbestos

The United States, although by far the largest user of asbestos fiber, produces only about 6 per cent of the amount consumed. The principal sources are Canada, South Africa and Russia. In this country the chief source is an asbestos mine and processing mill operated at Lowell, Vermont, by The Ruberoid Co., nationally known manufacturers of asbestos and asphalt building and insulating products.

Chrysotile asbestos is commonly found imbedded throughout serpentine rock and is mined in various ways, including underground, block caving, and open pits.

The appearance of an open-pit asbestos mine is much like that of a large rock quarry. The serpentine rock containing the fiber is first drilled and then blasted down. The blasted rock is put through a series of crushing and drying processes which reduce the material to proper size and condition for the extraction of the asbestos fiber from the rock that contains it.

Extracting the Fiber

Extracting the asbestos fiber from the crushed and dried, quarried ore is not a difficult or complicated process. Essentially the process consists of crushing the ore sufficiently to loosen the fiber from the base rock. After crushing, the rock is passed over a series of agitated screens and under a vacuum pick-up. The vacuum pick-up works essentially like a vacuum cleaner, and sucks up the fiber from the crushed rock. The rock is successively crushed and screened, and passed under vacuum pick-ups until practically all the contained fiber is recovered.

The fiber is then screened again to separate it into the desired commercial grades according to fiber length,

packed in jute bags and shipped. The grades run from long weaving fibers down to almost powdered asbestos, the latter being used as a reinforcer for certain types of molded plastics.

The bulk of the fiber produced in Vermont is used for the manufacture of asbestos-cement shingles, siding, and corrugated and flat asbestos-cement board, asbestos paper, industrial insulating materials of many types, saturated asbestos roofing and pipe line felts.

Building Materials

The basic method followed in the production of asbestos-cement building materials is well illustrated in the manufacture of roof shingles and sidings.

The raw asbestos fiber, after being thoroughly separated or fluffed and air cleansed, is mixed in huge beater tanks with exact proportions of Portland cement and water. If the product is to be of a particular color, the necessary pigments are added.

The liquid mixture or slurry next passes into vats containing revolving screen cylinders which pick up a web of the wet fiber thoroughly coated with cement and pass it along on endless belts to an accumulation drum which builds it up in felted layers to the desired thickness. The resulting large damp sheets are then automatically conveyed to a machine which cuts them into blanks approximating the desired shingle size.

The next step is that of passing the wet shingles through machines which press out excessive water and at the same time compress the material to the desired density and impress the surface with graining or texturing to add to their attractiveness. This is followed by thorough drying and curing processes, after which the shingles are automatically trimmed to exact size, punched for fasteners, and bundled for shipping.

A similar basic method is followed in the production of various types of asbestos-cement building board and the corrugated asbestos-cement sheets so widely used for roofing and siding industrial buildings.

In addition to shingles and sidings, The Ruberoid Co. produces an extensive line of asbestos pipe coverings, papers, millboard and other protective and insulating products widely used in American industry. Founded more than 60 years ago, the company developed in its first small plant in 1892 the first roll of ready-to-lay asphalt roofing ever made, marking the birth of a new industry. Later, entering the field of asbestos building material, Ruberoid became a pioneer in the development of roofings, sidings and insulating materials of asbestos and asbestos-cement. ●

Meaningful Applications

(Continued from Page 127)

all these symbols which they manipulate so glibly are full of meaning and tell interesting, true stories to those who understand their language. In short this process of interpreting symbols motivates the subject and causes the student to sense power, to perceive meaning, to think, and to obtain deep understanding. ●

"When private enterprise fades out of higher education in America, freedom, as we value it, will fade with it. We cannot permit ourselves ever to drift into a system of thought-control by which government, no matter how high-minded its officials, does all our educational thinking for us. We must maintain our private colleges and universities as islands of independence, not accountable to political authority but accountable rather to their own concepts of public welfare and their own non-political constituencies."

—Harold W. Dodds, *Pres., Princeton University*
The Liberal Arts—A Challenge to Communism
Assn. of American Colleges Bulletin, August '49

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"So, let the liberal arts college assert boldly, and without shame, that it wants the best of mind and character in its students, and that its function is to prepare such to be competent leaders; that it intends to attract and cultivate excellence in its students; to develop competent individuals—not just competent technicians, but people who are able to bring all human faculties into play."

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Chemotheraphy. Antibiotics

(Continued from Page 129)

been observed, however, that mixtures of bacitracin and penicillin may exhibit a greater activity than would be expected from a simple addition of their activities. This synergistic effect might prove to be of value in the treatment of refractory infections. Bacitracin is produced by a species of *Bacillus*.

Certain strains of *Bacillus subtilis* which are closely related to the bacitracin producer, elaborate another polypeptide, subtilin. This has been studied most intensively by the Western Regional Research Laboratory. It has a wide range of antibacterial activity but has not as yet been extensively studied clinically. Low solubility in the presence of tissue fluids will probably handicap its effectiveness. Preliminary chemical studies have indicated that both bacitracin and subtilin are highly complex polypeptides.

Various strains of *Bacillus polymyxa* produce a group of closely related materials, the polymyxins. These polypeptides, composed of relatively few amino acids, some of them of "unnatural" or *D* configuration, vary in their structure and toxicity. All are chiefly active in combatting infections caused by Gram-negative bacteria. Some clinical studies have been made on these materials but their status in medicine has not yet been fully determined.

Two recently announced antibiotics, chloramphenicol (chloromycetin) and aureomycin have similar ranges of activity. Infections caused by some Gram-negative and Gram-positive organisms apparently respond well to either antibiotic as do various virus and rickettsial diseases, such as Q fever, psittacosis, etc. Both antibiotics are produced by strains of streptomycetes but they appear to be different in structure.

Structural investigations on aureomycin have not been disclosed. This material was discovered and investigated by the Lederle Laboratories. Chloramphenicol, studied by workers at Parke, Davis and Co., is unique in that the structure has been determined and currently the production of this material is chiefly by synthetic means. It is thus the first useful antibiotic to be synthesized on a practical scale.

Numerous laboratories are working in the field of antibiotics on a large scale. There is every reason to believe that the list of therapeutically useful antibiotics will grow rapidly in the future. It is also interesting to consider briefly the growth of the industry as exemplified by the production of penicillin, the chief antibiotic from the standpoint of volume of production. Minute amounts of crude material were available in 1942 and 1943. Since that time production has increased astronomically as illustrated in the accompanying chart. The figures shown here represent the results of research by a large number of chemists, bacteriologists, pharma-

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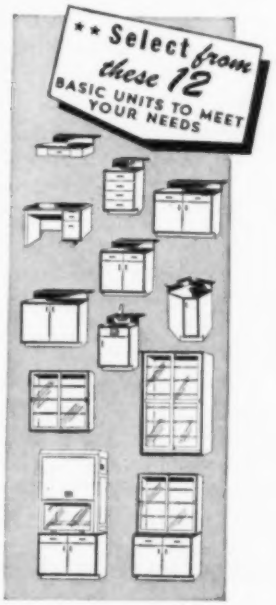

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cologists, engineers and other workers. Penicillin is now produced in a state of 95 per cent or greater purity in quantities undreamed of by the early workers who laboriously extracted small amounts of impure antibiotic from the low-yielding cultures available at that time. It is a striking example of the results achieved by coordinated team work applied to the development of a phenomenon observed and studied by a few brilliant pioneering workers. In the course of this development many phases of science have been involved, from theoretical physical chemistry to industrial fermentation technology.

Even while penicillin and other antibiotics are proving invaluable aids to medical science, their availability as research tools is making possible fundamental advances in many branches of the natural sciences. It is our belief that the future will bring many more important advances both in the agents available to the medical men in their battle against disease, and in our understanding of the life processes of the bacterial cell and also higher organisms. ●

Work on Deficiencies

(Continued from Page 122)

The use of mineral supplements where needed, now takes care of farm animals which are fed grain in addition to hay and pasture. But a great many animals which live mainly on pasture and naturally cured forage do not receive an adequate mineral supply. The improvement of field crops through the supplying of necessary mineral elements aids not only in increasing feed production, but in correcting mineral deficiency as well.

Phosphorus deficiency was found in Minnesota in 30 counties on certain glacial soils in the western part of the State. Typical phosphorus deficiency was also found in the southeastern part of the State on prairie soil which had been under cultivation only 60 years.

In Michigan, the phosphorus content of both the stems and leaves of alfalfa grown on soil which did not require additional lime was increased by the application of superphosphate alone or in combination with potash. Alfalfa grown on heavy-textured soils contained more nitrogen and less phosphorus than that grown on light-textured soils.

In southeastern Kansas, on acid soil it was found that superphosphate alone did not increase the percentage of phosphorus in alfalfa but superphosphate and lime did. The calcium content increased in proportion to the amount of lime applied.

On eastern Washington soils, the phosphorus and potash contents of alfalfa had a tendency to increase as a result of superphosphate and potash fertilization.

The Utah Experiment Station found that, on a calcareous soil high in total but low in available phosphorus, wherever the use of manure or phosphate increased the yield of alfalfa it also increased its phosphorus content. The increase was as much as 80 per cent in some cases.

In Wisconsin Kentucky bluegrass receiving a heavy application of nitrogen produced 4.4 times as much crude protein as grass not fertilized with nitrogen. Phosphate fertilizers increased the phosphorus content, while phosphorus and potash increased the nitrogen content.

In an experiment in southern Illinois, it was found that sweet clover contained 35 per cent less nitrogen and 67 per cent less phosphorus per acre on soil receiving lime alone than on soil receiving lime, superphosphate and potash.

At the Kentucky Experiment Station, analyses were made of 34 samples of lespedeza hay grown on different soils in the State. All the hay from the poorer soils was low in phosphorus and usually low in protein content, whereas hay from the better soils was much higher in both phosphorus and protein. For example, lespedeza grown on certain limestone soils contained .32 per cent of phosphorus and 1.28 per cent of calcium, but when grown on soils outside the limestone area it contained only .14 per cent of phosphorus and .89 per cent of calcium.

Fertilized pastures on one Virginia soil contained up to 39 per cent more crude protein and 47 per cent more phosphorus than untreated pastures.

Many other examples of the influence of fertilizers on forage composition could be given.

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Meeting the Situation

Some crops take away more plant food than others. A 10-ton tomato crop uses six times as much potash as a 30-bushel wheat crop. A 300-bushel yield of potatoes uses five times as much nitrogen as a 4-ton crop of grapes.

What is used must be replaced. Every last bit of material available—weeds, cover crops, and crop resi--dues—should be turned back into the soil because of the valuable organic matter and plant food they contain.

Manure—supplemented with superphosphate—should certainly get back to the land.

Where soils are acid, liming materials are needed.

Even all this is usually not enough.

Fertilizer also should be added, for it feeds back to the soil the plant food needed to grow good crops—crops that the farmer brings to harvest.

The plant foods usually lacking are nitrogen, phosphoric acid and potash. Whatever the lack it must be supplied to produce quality products.

But American farms still produce excellent crops. The good soils that the Creator of the Universe gave North America are still the continent's great basic resource. They have grown great harvests. They will grow many more—even bigger and better.

The reason is simple. The men who farm these soils have learned much. One of the great principles they farm by is simply this: What the soil lacks, plants cannot get and man and his domestic animals will also lack. Farmers can now see the hunger signs of the land in the crops that suffer as they grow. Reading these signs they can tell what to add to the land to nourish well the crops, to feed strong healthy livestock, and to send to the markets good harvests that please the eye and provide health and strength for a great and happy people. ●

NOTE

The National Fertilizer Association, Investment Building, Washington 5, D. C., has a movie entitled "Hunger Signs" which is available to schools on a loan basis free of charge except for the cost of transportation.

★ ★ ★ ★ ★

"Too many modern pedagogues contend with all seriousness that proper education is informative education—if only one can make the field of facts both immediate to the student and widening to his general interests—instead of functional, as the older and wiser pedagogy always insisted. In their desire to be advanced in educational thinking many of those who teach teachers have reverted to the most primitive of educational notions, that an educated man is one who merely relates himself to his environment. They have forgotten that a really mature and effective person is one who, having discovered his environment, has learned how to relate that environment to himself, courageously and successfully."

—Bernard Iddings Bell
Crisis in Education

"As a plain matter of fact, most college freshmen, charming lads and lasses though in many ways they be, cannot do the things that may reasonably be expected of them if they are ever to become mature thinkers or effective workers. They cannot look at a thing and tell you what they see; listen to sounds and know what they hear; by the touch truly perceive form; sense how others feel and why; read, write, speak with any sure knowledge of how words are to be handled or of what other people's phrases mean; or, finally, think in general terms as distinct from specific and concrete particulars. It is difficult properly to teach them science because they know next to nothing about sense perceptiveness; to instruct them in morals, manners, politics, history, or religion, for they have not begun to learn how to evaluate and respect other persons; to impart knowledge of philosophy to those who do not know what "abstract" means; or to do much of anything with them until one has taught them to read, write, speak, cipher, and observe with the five senses."

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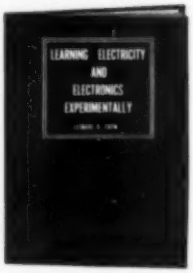

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The Sky Compass

In polar regions the magnetic compass loses its value as a direction indicator because of the weakness and directional variability in the horizontal component of the earth's magnetic field. In addition, a primary handicap to navigation has been the lack of a direction reference during long twilight periods when neither the sun nor the stars can be used. Considerable modification of conventional methods of aircraft navigation has therefore been required in such regions, where magnetic compasses and other existing instruments are inoperative. To meet this need, the National Bureau of Standards has developed a sky compass which indicates the direction of flight from which, with other data, the position of the aircraft can be determined.

The sky compass which is based on the investigations made by the late Dr. A. H. Pfund of Johns Hopkins University, is an outgrowth of his twilight sextant. It operates on the principle that the light of the sky during the day is partially plane polarized, the polarization being a maximum at right angles to the incident beam from the sun. The plane of polarization at any point in the sky thus contains both the observer and the sun. Establishment of this plane also gives direction since it points to (or away) from the sun.

The principal advantage of the sky compass over the sun compass (which measures the direction of the sun directly) is its use during twilight, and when the sun is several degrees below the horizon, as well as when the region of the sky containing the sun is overcast, so long as there is a clear patch of sky overhead. The sky compass is thus of particular value when the sun compass and the sextant are not usable, after sundown before evening stars appear, and after morning stars disappear but before sunrise. Since the extent of polarization of the sky's light is greatest at right angles to the incident beam of sunlight, the compass is most accurate in the polar regions, where it is also most useful, because of the long duration of twilight and the weakness and inaccuracy of the magnetic compass at high latitudes.

Essentially, the sky compass consists of an analyzer for determining the plane of polarization of the light, an azimuth circle on which the sun's computed azimuth can be set, and a clock which drives a chosen reference line in synchronization with the sun's apparent motion, that is, one revolution in 24 hours. For convenience in observing a portion of the sky around the zenith through the analyzer, the analyzed beam is turned from vertical to horizontal by means of a mirror. ●

★ ★ ★ ★ ★

"Science is not a cold, impersonal accumulation of facts—sheer, stark facts. Science is an accumulation, to be sure; but it is more. It is association, integration, interpretation, and understanding of ideas and facts by men and women."

—Ideas, Men and Things
J. O. PERRINE

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